

BeoCreate Elements: Designing an open loudspeaker

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Designing an open loudspeaker

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Abstract

For hundreds of years, we have developed our society, production of goods and distribution to be the most efficient and profitable. That development has led us to a situation where the natural resources cannot stand the current development anymore. For this reason, we need to find new production and distribution systems, which reduce the impact on nature.

In recent years some production methods have developed becoming more affordable to masses than before. 3D-printers and CNC-routers, for example, provides the opportunity to average people to produce goods locally. At the same time, the movement of open-design has spread making it possible to share designs without complicated product copyrights. The development of Internet makes it possible to design globally and share the designs locally. Therefore we have all the tools to start designing for local manufacturing, local materials, and local communities, in digital era.

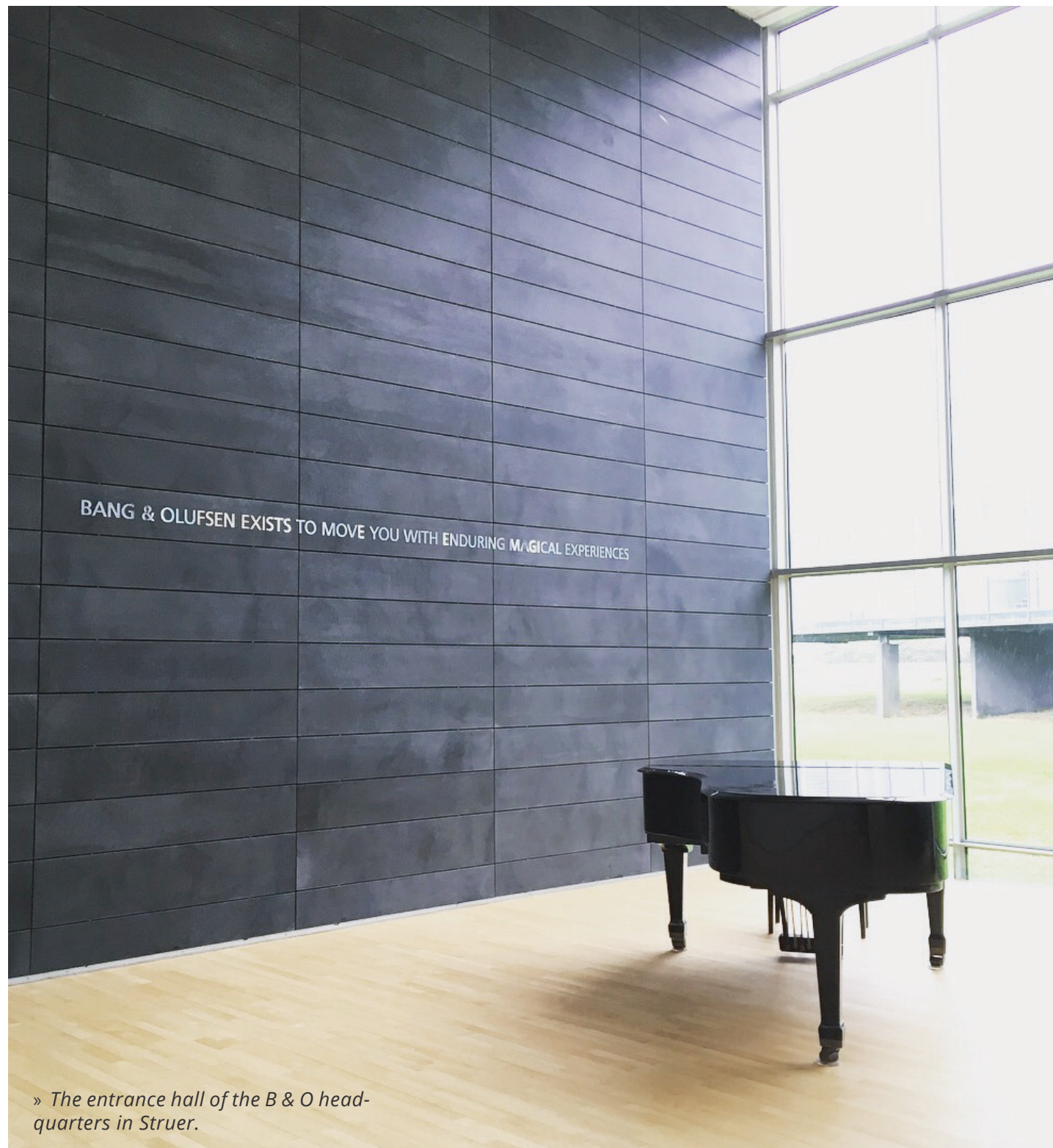
In this thesis I explains why we need to start designing for local manufacturing and materials. Besides, I describe how the development of production methods and digital tools could contribute to a local manufacturing. Based on the knowledge I designed a loudspeaker system for audio company Bang & Olufsen. The system takes into account the use of local materials and business opportunity, but also the benefits that digital tools has to offer.

For the concept development, I used Roberto Verganti`s Design-driven innovation method loosely. As a result, I propose a product which works as an example of designing for local manufacturing. The product design followed existing principles of open design. The experimental process

showed me that designing for local manufacturing needs the change of mindset from a designer. Designing for openness and local manufacturing results somewhat simple products, and there is a reason for that, which is the need of replicability.

In the end, I propose that the practice and principles of open design should be explored more. The field of open-design is now scattered and under constant development. Therefore it is hard to specify the right methods and practices for open design and local manufacturing. The development of open-design and local manufacturing potentially creates new businesses and local empowerment. This thesis is a good example of how corporate is looking for future, emerging markets and trends. Eventually, smaller companies, individuals, and others will follow.

Besides the product development, the thesis reveals how a corporate using design-driven innovation method can use external parties for exploring, and producing new concepts.



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CHAPTER 1: Background



» Model N°0, the speaker I designed in the Form exploration -course.

1.1 Introduction

In 2016 I attended Form exploration course at Aalto University, which was led by university lecturer Simo Puintila. The course was company collaboration with Bang & Olufsen CREATE. The company appreciated the work of mine, and later discussion with the Concept and Project Manager for CREATE Christian Thams led me to thesis opportunity with B & O CREATE.

Further discussion with Christian Thams led to a decision that I would move to Copenhagen at least for the time of thesis work. I would be working on the premises of Bang & Olufsen in Lyngby, and they would provide me all the needed material and support for the concept and thesis development.

Tuomas Hämäläinen who is a fellow CoID student at Aalto ARTS was provided the same thesis opportunity by B & O CREATE. The ideas that we had overlapped at some points, so we proposed to B & O CREATE that we could do the project as teamwork. That was because we both have our areas of expertise and we would complement each other. The collaboration would benefit both of us and the aims of B & O CREATE.

Thesis structure

In the first two chapters, I introduce the background for the project. In the third chapter I present the literature about sustainability, its history, current state and sustainable design strategies. In the fourth chapter, I describe the product design process, which is informed by several parties. In the last chapter I discuss about the process and future opportunities.



» The headquarters of B & O is called The Farm. It is designed by KHR architects, and the idea of its see-through construction is to bring the B & O's heritage in the countryside close to employees.

1.2 Bang & Olufsen

The company is mainly known for its high-quality audio products, but also its distinctive design. This match of creative thinking and precision engineering is a result of artists and engineers vision. Peter Bang and Svend Olufsen founded the company in 1925 at Struer, northern Denmark. Their first product was a radio and ever since they and their employees have kept going with innovations and striking designs. The company was one of the few backs then who used external designers to develop new products and that heritage we can see today.

Nowadays Bang & Olufsen is a world-renowned brand, and the company is an employer for around 2000 persons in several countries. The headquarters is still located in Struer. There the company has its innovation labs, product development and aluminum factory. In the Czech Republic, Bang & Olufsen have assembly and manufacturing facilities. Also, some of the parts are manufactured in China and then shipped to Europe for assembly.

Bang & Olufsen have set of business divisions, for example, B&O PLAY for portable solutions, B&O Home for domestic listening and Car audio systems with Harman. On top of that, the company is actively collaborating with other brands.

For serving the internal and external innovation, collaboration, inspiration and development B&O has founded B&O CREATE.

Bang & Olufsen CREATE

"CREATE is a motley crew of deeply passionate people from all corners of Bang & Olufsen that devote all, some or little of our time to pursue our vision. We have the freedom and maneuverability of a start-up, yet the muscle, knowledge, and heritage of the 92-year-old company. In essence,

CREATE is an open platform on which we can do things differently, and you're invited to join."

CREATE is an explorative initiative within Bang & Olufsen. Its actions are based on openness and curiosity where the process and failure are as essential aspects as a result. The initiative aims to collaborate with different parties such as universities, maker spaces, tech. Savvies and other explorative movements. The explorations and learned subjects are then fed to the mother company. But above all, the transparency, sharing, and learning are the guiding principles of the movement.

1.3 Teamwork

The project of mine and Tuomas's will be the same, but we will approach it from different angles. We both will hand separately written thesis. They will be concerning different aspects of the project. Tuomas will be in charge of the technical development whereas I will be in charge of the product and concept implementation.

As the old phrase says, 1+1=3, the same applies here. The topic of our work is complicated. It requires extensive knowledge of technology and its different future opportunities, but also how that will fit into the future society, and customers use. Tuomas has a superior understanding of technology and its various aspects. He knows how to execute fully functional products which work as we want it to work. Instead, I have developed my skills in meanings, concept design, and fitting designs into society.

We believe that our skills will complement each other and we will be able to tackle broader scope, than doing the work individually.

1.4 Objectives

The following is the initial task given by Christian Thams from B & O CREATE:

“The objective of this project is to investigate how we might reuse the hardware developed for ReCreate to expand our community and power new collaborations.”

“BACKGROUND

In September 2017 Create is launching ReCreate for public availability. To realize ReCreate, a Raspberry Pi powered DSP and amplifier board was developed as the hardware to power and upcycle vintage loudspeakers. This hardware can be used for other projects as a multipurpose loudspeaker tool.”

OBJECTIVE

The objective of this project is to investigate how we might reuse the hardware developed for ReCreate to expand our community and power new collaborations.

DELIVERABLES

Design a system, based on ReCreate hardware, for artisans, designers, and makers that can be used for loudspeaker projects that encourage creative exploration. A demonstrator of the results will be presented for Bang & Olufsen.”

Research objectives

The initial objective was to look how open design and local manufacturing could improve longevity. Along the way I had a chance to discuss with the head of the concept exploration, Lyle Clarke and the objective started to take a new direction. Mainly because of Lyle`s opinion: *“The reason to remove the longevity is that the world is changing so much these days, and circular thinking is becoming the new longevity. Change is good.”*

Therefore the research objective changed to how we could use open design and local manufacturing for new sustainable loudspeaker design.

Brief

Implement open-design loudspeaker system for a home environment.

1.5 Context

Bang & Olufsen has been around for 92 years and had had its ups and downs. But above all, it has been the crown jewel of Danes. Formerly the company has been like folks brand, but the last 20 years have been different. The company has positioned itself as luxury and high-class brand. This project is about looking a bit back and trying to bring the products back to reach of average citizens and consumers.

In global business and manufacturing chains, the product components and parts are often manufactured overseas, whereas assembly and retail happen somewhere else. At Bang & Olufsen, aluminum components are produced in Denmark, technical parts in the Czech Republic and assembly in China. This kind of manufacturing chain means a lot of shipping goods around the globe. Which in the first place means vast emissions and use of natural resources. But also in product-wise, it means mass manufacturing of similar products, in a world where customers demand customized products.

The recent years have been pointing out that technological development is providing a lot of new possibilities. Circuit boards have become accessible for the masses and manufacturing methods, such as CNC routing, laser cutting, and 3D printing are allowing us to manufacture products locally. The new techniques have led to democratization where more and more people will be able to build electronics and physical products. The technological "openness" is called open-source or open-design where the code or product is available to anyone to explore, build and develop. These people who tend to play with these new possibilities are usually called makers, but the group of people are continuously expanding to artisans, designers, and other people.

If there is a product, there is a business opportunity. The business models around local and open making are taking huge steps at the moment, but still there is not any standard or established models. Different parties, makers, and designers are exploring that world to be in the first rows for getting the financial profits, with sustainable manner.

» BeoRemote One remotes in the making in the Struer factory.



Photo: Tuomas Härmäläinen

Personal motivation

Being given the task from a company already sets a specific type of frame for a project. It gives me responsibility and possibilities to learn, but also affect one way or another to the company. That being the case, the topic felt very personal, so I wanted to write a short reflection about it.

Why it feels personal is the nature of the project as the experimental projects are somehow close to my intentions in the field of design. It allows me to try and propose new working methods for ever-changing field of design.

In the recent years, the development of manufacturing methods has made local manufacturing more affordable for mainstream citizens but also for corporates. Local manufacturing is seen as a feasible strategy for sustainability and product innovations. In my opinion, corporations are from their part responsible for adopting new possibilities and spreading them into the societies, in the name of better future. Therefore I feel it very personal to be able to propose something new for Bang & Olufsen, which have the power to change things towards better future. I am not stating that sustainable way of manufacturing loudspeakers is saving the world, but I believe that corporates should lead the way there. Eventually, others follow, even the small ones. That is a reason why this sort of projects are important.

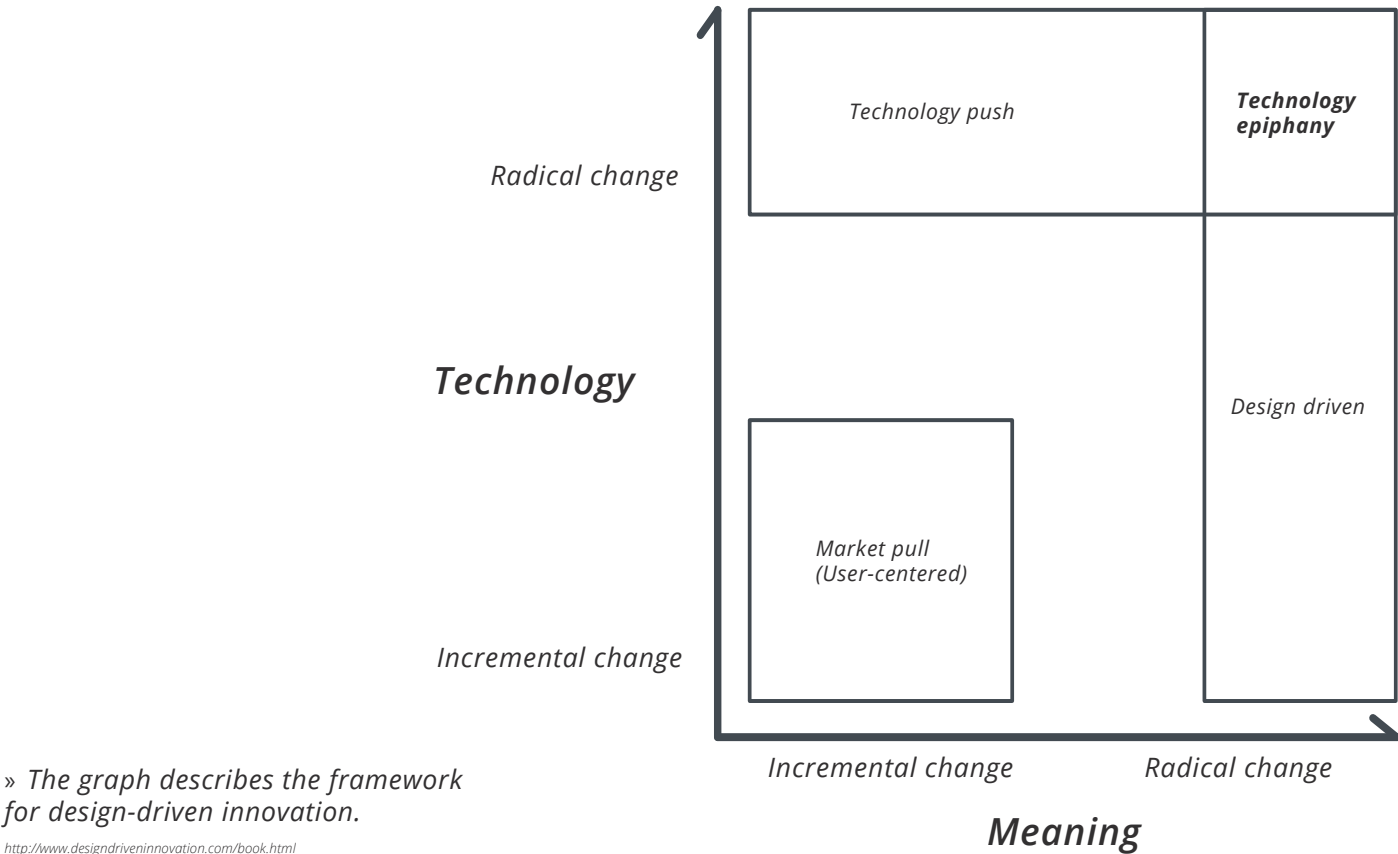
I hope this work would also support my professional development as a designer. I feel the responsibility for better future, and in that sense, I should know the strategies and ways to design more responsible products. In the future, I believe that professionals who have focused on sustainability, are wanted, employees.



Photo: Tuomas Hämmäläinen

1.6 Methodology

This thesis is a production-based study where a product will be the result. The conclusions will be drawn from the process of product development. The methodological framework will loosely follow Roberto Verganti`s design-driven innovation strategy, where instead of following user-centered methods strictly, the process will be guided and informed by technological opportunities and changes in society. The reason for using the DDI, is that dealing with emerging trends and practices, requires a process which supports new product innovations. Nevertheless, as we are dealing with products that people use, I will be conducting user research to inform the design. Design-driven innovation will not be the subject of study, but more like framework for the project.



Design-driven innovation

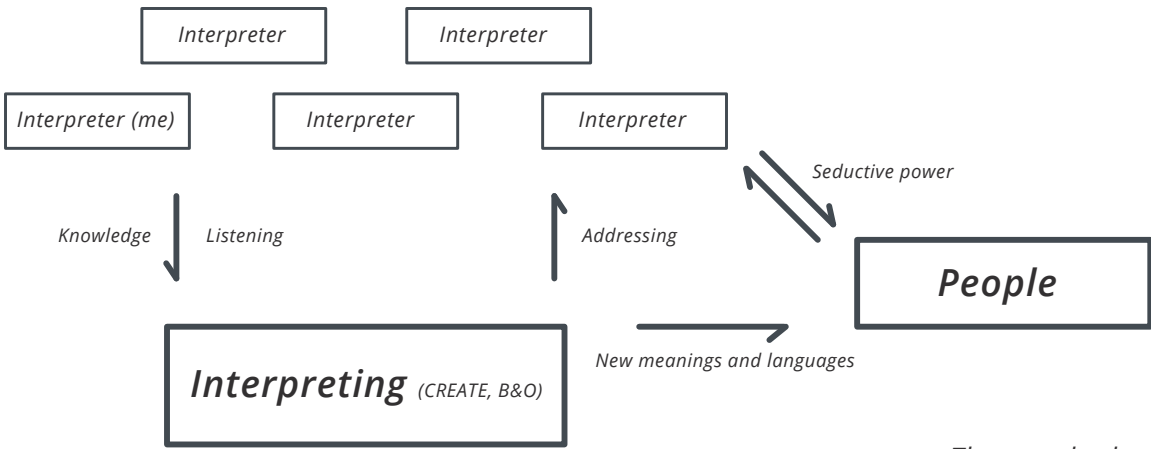
Design-driven innovation is a strategy established by Roberto Verganti, professor of management of innovation at Politecnico di Milano. The approach is focusing more on proposing new products with new meanings, rather than something that customers already recognize. The process seeks new meanings from different interpreters in the society and afterward interprets them into product proposals. Another factor in the process is the technological development, which combined with new product meaning is a powerful way for innovations.

In my process, peoples` perceptions towards loudspeakers will be gathered with focus group interview sessions. More specific questions about product replacement and needs from loudspeakers will be collected with an online survey. The results will be used to inform the design and what should be taken into consideration. Possibilities

of technology we have, open design and local manufacturing will be assessed to find how could we use them in creating a new type of product which promotes sustainability.

Verganti`s map of DDI process shows the different stakeholders of the process. My thesis will be one of the interpreters and CREATE, instead is the party who is interpreting new ideas and feeding them into Bang & Olufsen, and eventually providing new meanings to customers (people).

In this thesis, I will be interpreting the maker culture, user research, technological opportunities, and other cultural aspects to find new product possibility.



CHAPTER 2: Relevant concepts

In this chapter, I will explain the foundational concepts of the thesis. I will briefly describe music systems, but the focus is more on the hardware that I will be using. Open design is a relatively new concept, and therefore I explain the different aspects of it. Last I will talk how local manufacturing is intertwined with the open design.

2.1 Music systems

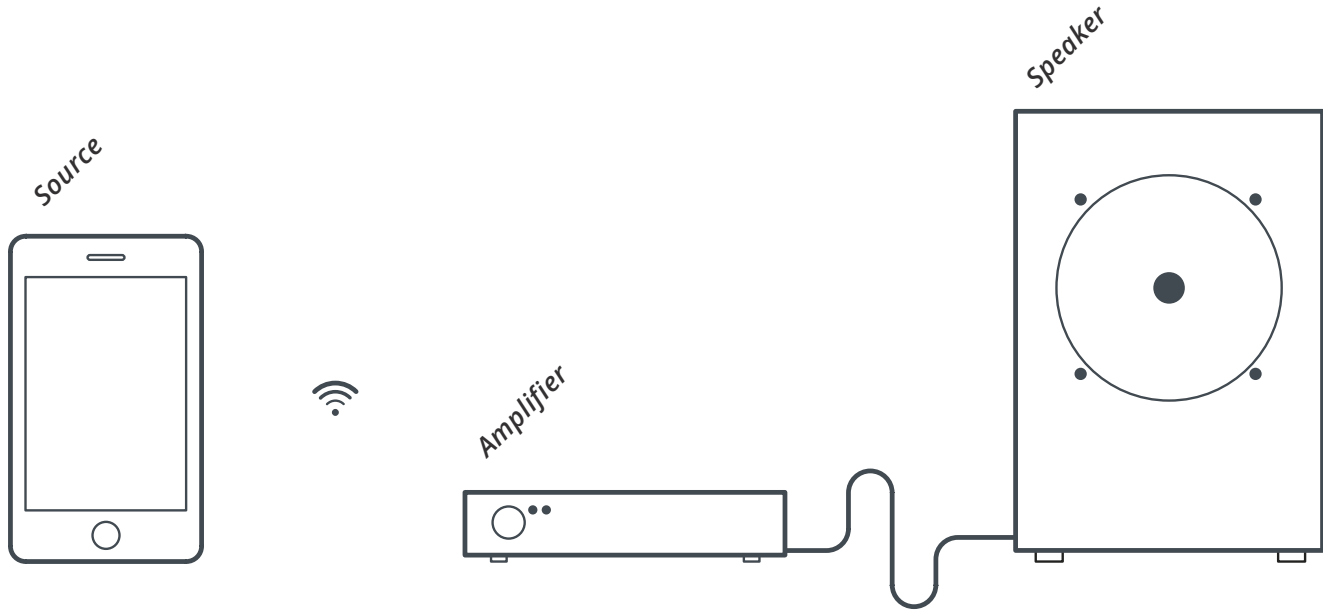
Playing music is one of these subjects in the world where one can dig very deep. Digging very deep requires extensive knowledge of technology, acoustics, electricity to name a few aspects of it. I do not feel it necessary to go to the details here, because what we need in this project is rather simple. What we need to hear music is, speaker cabinet, drivers mounted to cabinet. To play the music, we need the source, for example, a laptop or smartphone. For wireless streaming, we need a computer to receive the data from a source. And, finally, for powering up the music, we need to amplify the digital signal and convert it to analog for the drivers. The latter is very basics what happens nowadays with almost every playing loudspeaker system, in many different configurations.

Hardware

As my brief from Christian asks, I should be utilizing the CREATE 4-CA board which CREATE has developed together with German audio company called Hifiberry. Therefore I feel essential to briefly introduce the hardware side of the project, even though Tuomas will be in charge of that in his thesis.

Consuming music has changed from the times of gramophones and vinyl to these days dramatically. The technological changes such as the Internet and wireless inventions has provided the opportunity for direct streaming of music without any physical objects. It means that we can play the music straight from our devices, such as smartphones or laptops wirelessly via WiFi or Bluetooth. As we are living in the digital world, we are nowadays also able to modify the digital signal, read, sound. These are the basic functions that the newly developed board offers to us. Next, I will explain the basics of the hardware that CREATE 4-CA -board is providing us.

» The picture illustrates how sound system often works nowadays. It has a source, which connects wirelessly to an amplifier and speaker.



DSP - AMP - RaspberryPI

The CREATE 4-CA -board, developed with Hifiberry consists mainly of three functions, DSP (Digital signal processor), Amplifier and RaspberryPi computer chip. The combination of these components allows the user to stream music wirelessly, manipulate the sound digitally and amplify four drivers.

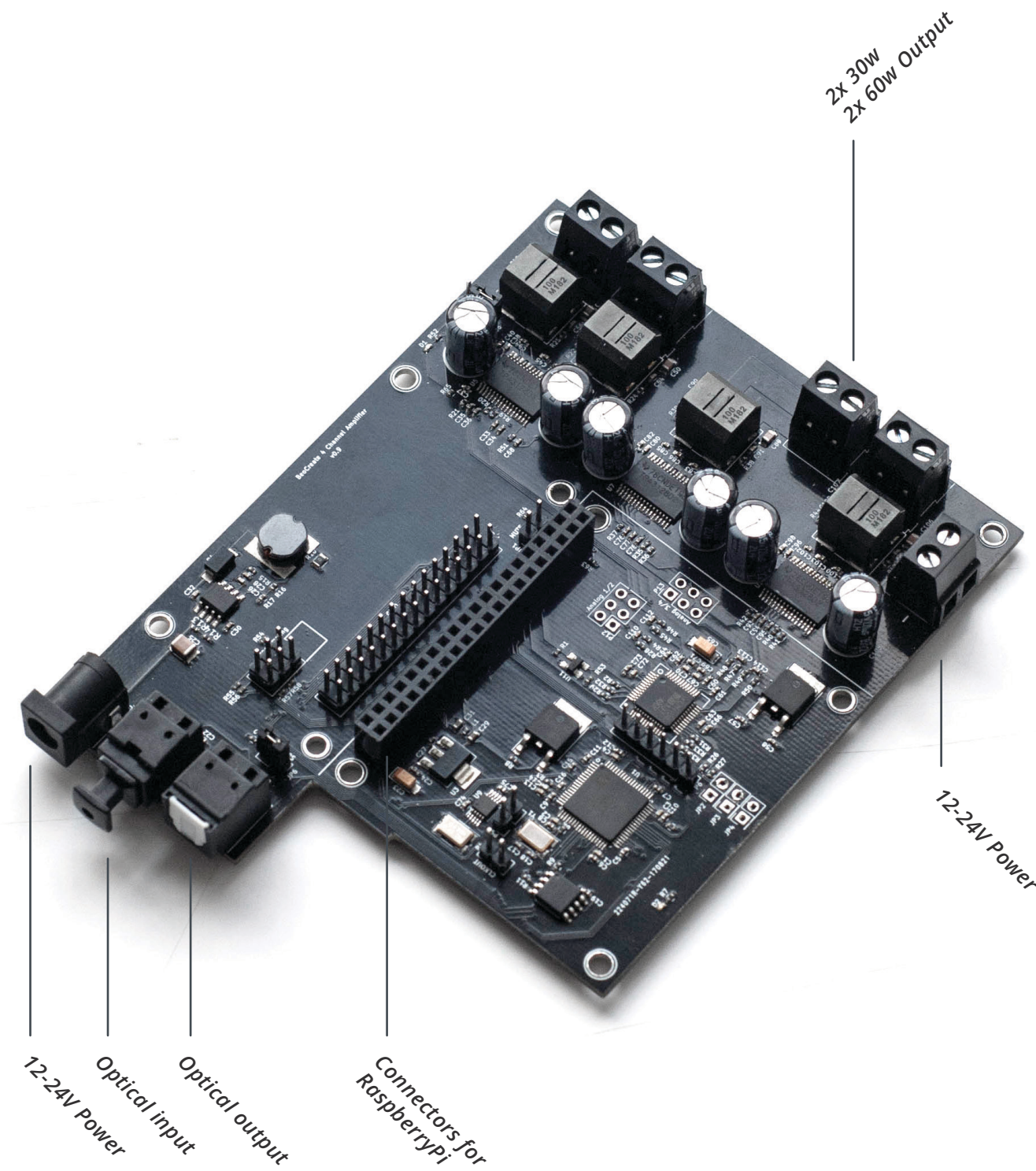
Digital signal processing is technology that, from its part enables Bang & Olufsen`s unusual speaker designs. With DSP the sound can be tweaked into wanted direction or pumped up even if the physical speaker cabinet design would not allow it.

The amplifier powers up the digital signal from the digital device for the drivers which make the sound. The board has four channels, 2x30w and 2x60w which means that it can amplify four drivers. For example two tweeters and two bass drivers, or two bass drivers and one tweeter.

RaspberryPi is a computer chip, which runs with different operating systems, for example with Linux. The 3rd generation RaspberryPi has wireless capabilities which enable for instance music streaming straight from the phone or computer. It also has an optical input/output and HDMI connectors which enable attaching external appliances. RaspberryPi serves as nerve center of the board, allowing the user to use it for countless different applications.

The opportunities of the board lie on the possibility to attach sensors, triggers, and other digital or analog devices into Raspberry and therefore control the sound with different applications. It means that the board would be a potential tool for example building installations or anything that combines sound, visuals, and physical objects. And, of course, it doesn't have to be anything complicated, the board can also power passive loudspeakers without anything "special." A good example of that is CREATE`s ReCreate project where the old B&O CX50s` and 100s ` speakers are powered by the board, making them from passive to active speakers. For additional information: <https://www.hifiberry.com/beocreate/>

Knowing the all possibilities was interesting, yet challenging departure point for this project.



» The RaspberryPi chip will be attached on top the 4-CA board.

2.2 Definitions of openness in design

The reason for looking into the open design is that B&O CREATE grounds its work for sharing and collaborating. Taking the strategy of opening the specific projects is a decision of the mother company Bang & Olufsen. Therefore I will describe briefly three concepts of openness and will stick more into “open design” as it is the other foundation of my project, besides local manufacturing.

Based on the papers that I have read the discussion and practice of openness is still scattered, but terms that rises regularly are open-innovation, open-source design, and open-design. They all differ regarding how they work in practice and the level of openness. Avital describes the differences in the book “Open design now – Why design cannot remain exclusive” with following characteristics.

Open design as a phenomenon, as Avital explains ‘covers an extensive area, and its contours are not yet clearly defined, making it difficult for designers to come to grips with.’ (Avital, 2011).

Open innovation means mainly larger organizations are opening their knowledge to the public in terms of finding new business models. Whereas open source design refers to software development by developer communities. The communities are working on several information sharing platforms. Whereas open-design means that the product is opened to the consumers who engage in manufacturing chain. (Avital 2012).

Describing briefly the three concepts of openness in design I wanted to show that the openness has arguably potential to spread into businesses at all levels, slowly but still gaining constantly more foothold in the field.

The open design differs from the other openness definitions in the sense that it is leaning towards manufacturing and therefore concerning physical products. As Avital suggests, the value proposition of open design is ‘distributed manufacturing’ where the consumers have the prominent role. In the Generative bedrock of open-design, Avital also draws foundational factors that creates open-design. Achieving the openness a designer needs to take care of products accessibility, reconfigurability and sharing the blueprints under open access license. (Avital 2012).

According to Howard (Howard et al. 2012), we are at the moment living in the post-industrialization era where information has become the currency of distribution, therefore changing the product manufacturing and development processes. In practice, that means decentralization of the manufacturing and development. Based on my own feeling, we have used to a model where we buy products, which parts have been manufactured all over the world and assembled in one place, and finally shipped to customers. According to Doustmohammadi in this classic, centralized model only a few agents are responsible for the developing, producing and supplying products. These products are usually mass manufactured and seeking to meet customer needs. In contrary, the decentralized developing and manufacturing model is open for all agents to participate in the different steps of the whole chain. (Doustmohammadi et al. 2013) That refers heavily to local manufacturing, which I will introduce later. Because of possibility for participation in all stages and restrictions in the manufacturing, the products made in a decentralized model are often more simplistic, but more diverse and customized as well.

Juxtaposing archetypes of open-x	Open innovation	Open source	Open design
Value proposition and thrust	Distributed knowledge	Distributed development	Distributed manufacturing
Core openness facet	View	Modify	Use
Prime actors	Organizations	Developer communities	Consumers

» The graph is based on a image in opendesignnow.org <http://opendesignnow.org/index.html%3Fp=405.html>

“open design is directed towards consumers who engage in fabrication, passing over the conventional manufacturing and distribution channels.” (Avital in Open design now. 2012. P. 49-58)

Pros and cons of open design seem still to be unclear, but based on Howard’s research there is three definitive benefits and challenges. The benefits are the mass of developers which causes evolution in the products. The fast distribution and promotion are achieved by local manufacturing methods. The mass of developers creates a lot of variants from the products. (Howard et al. 2012) The benefits seem to mean fast product developments and customizable solutions for local needs. Based on locality, it also reduces costs and is friendly to nature.

The first challenge is the required skills for making and manufacturing physical products. The fact is that not everybody can make, have the needed equipment or have the will to make products by themselves. Whereas open source software development is relatively free, the manufacturing of physical products requires some investments for the materials, tooling costs, etc. The second concern is that there isn’t partial open design. That means that the impact of open-design is not organized into any system, unlike open source software development happens on different coding platforms. The third problem according to Howard is the validation. The community cannot validate the complex design, e.g., cars, etc. It naturally causes concerns about safety in openly designed products. (Howard et al. 2012)

“Open design is more than just a new way to create products. As a process, and as a culture, open design also changes relationships among the people who make, use and look after things. Unlike proprietary or branded products, open solutions tend to be easy to maintain and repair locally. They are the opposite of the short-lived, use-and-discard, two-wash-two-wear model of mainstream consumer products. As you will read in the pages that follow, “nobody with a MakerBot will ever have to buy shower curtain rings again.” (John Thackara in Open design now. 2011)

The distinct features of open design

	Open design is...	Open design is not...
Access	Available, sharable, licensed under open-access terms	Concealed, protected, licensed for a fee
Blueprints	Specified by common digital notation language	Specified by proprietary notation language
Derivatives	Reconfigurable and extensible	Black-boxed and fixed
Exclusivity	Reproducible	Developer communities
Means of production	Fabricated by commercial, off-the-shelf, multi-purpose machines	Fabricated by artisan handwork, custom-built machines or moulds
Manufacturing process	Subject to distributed and scalable production	Subject to centrally controlled and preset batch production
Potential	Generative	Closed-ended

» The graph is based on a image in [opendesignnow.org](http://opendesignnow.org/index.html%3Fp=405.html) <http://opendesignnow.org/index.html%3Fp=405.html>

Stakeholders in open design

Making things open is breaking the old barriers between manufacturers, designers, and consumers. Traditionally designer designs the product in one place, a manufacturer produces the product somewhere, and consumer consumes the product in third place. First of all, the current and traditional way is very unsustainable, but also it produces products that might be relatively far from the users' real needs.

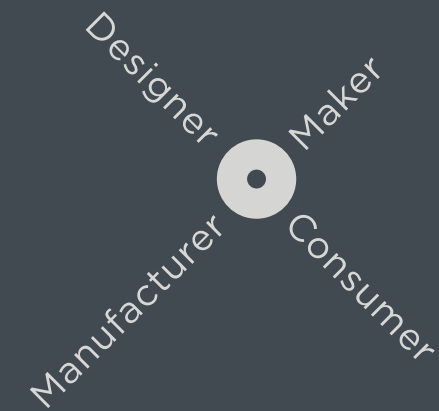
Publicly available production methods, Internet, and new digital software solutions are changing the way who can be a designer, manufacturer or consumer. Making it simple we can think of a scenario where the consumer designs a product with free software, goes into a local manufacturing facility, manufactures the product, and in the end, consumes it. The consumer then had an opportunity to contribute to every step of getting the product, she/he needs. A consumer can be designer-manufacturer-consumer, still noting that manufacturing requires motivation and skill set from the person.

There are different variations from this, for example, professional designers might be designing products for consumers who will manufacture them at local manufacturing facilities. There might be occasions where the consumer designs a product, but local manufacturer produces it and everything between these.

The common aspect in all cases is the fact that there are no strict, classic barriers between different stakeholders and everything that is produced is open for everybody to modify, replicate and make.

The blueprints, notes, and instructions are often shared on the Internet. There are several platforms, which are dedicated to the open movement. People are posting their designs there for other people to modify, customize and reproduce. Some of the platforms are instructables.com, thingiverse.com, and openstructures.com. As far as I have noticed, an open-design still lacks one central platform, like github.com is for open source design.

"The common aspect in all cases is the fact that there are no strict, classic barriers between different stakeholders..."



2.3 Local manufacturing

Local manufacturing means that the product is manufactured within close distance of end users, and not overseas. In the end what has made local manufacturing possible, is digitally controlled manufacturing. In the mid-2000s the relatively small-scale digital manufacturing technologies have become more prevalent in the market. *(Richardson, 2016)* That has led to extensive use of these machines, mostly by the maker movement. The most commonly used machines are CNC (computer numeric controlled) machining, 3D-printers and laser cutters among more traditional workshop machinery.

What differentiates local manufacturing from traditional, centralized manufacturing, is that it usually takes place in urban environments and does not fit into a definition of large-scale manufacturing facilities. In recent years the local manufacturing facilities have popped up all over the world. The fab-labs are one good example of them. These facilities offer a previously mentioned manufacturing equipment as well as electrical and software support, making it possible to produce a large variety of functional products. Often these facilities are in constant change, and the repertoire of machines and equipment depends on the technological development and the needs of the people who use these facilities. Local manufacturing is not only a sustainable way of producing products, but it is also seen building communities around these facilities. The benefit of communities is that ideas spread and will be executed, and companies founded. Producing open-design products in these kinds of environments also might be a starting point for new innovative solutions for companies as well.

Local and digital manufacturing could be considered as the new realm of craftsmanship, which well-done adds value to the products similar to the

classic craftsmanship. Culturally local craftsmanship has been appreciated and seen to give a lot of extra value to products. The coming years will show how appreciation will develop towards new ways of manufacturing. I can see there are already groups which appraise them, but it is not yet very mainstream, even though the large masses have noticed the new possibilities.

Digital tools / manufacturing

In the context of design and manufacturing, digital tools can refer either to software or hardware, or combination of those. In this thesis, digital tools will refer to digital design software that is used for designing products. Digital manufacturing will instead refer to hardware tools that are controlled digitally.

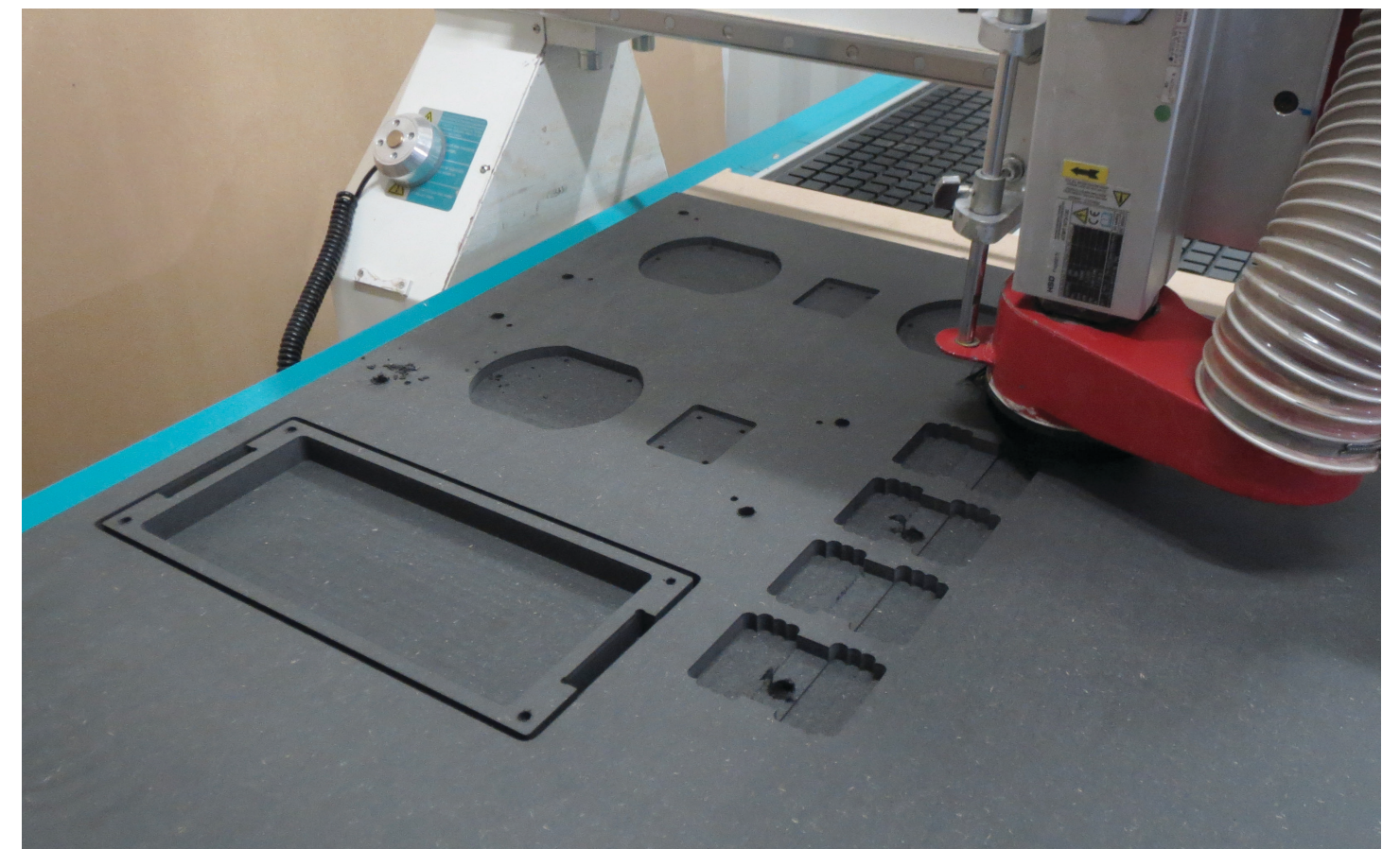
In most cases, digital manufacturing is based on digital tools and modeling. Digital modeling tools allow the maker or designer to create, evaluate and modify the designs virtually. After digitally modeling the object, specific data is sent to a machine which then cuts, prints, extrudes or shapes the whole object or parts of it.

What digital manufacturing enables is that products can be made locally and with low-costs for niche markets. Anyone could be, with a somewhat small effort the manufacturer of their products. As the products are based on computer models, which can be easily customized, replicated and modified, fulfilling a local and personal needs is easier than ever. Another factor that makes it possible is the ever faster and readily available internet connections. *(Hagel et al. 2015)*

Accessibility for the tools varies a lot. Digital programs are relatively accessible for everyone, and the lowest prices are something between free and very affordable, but highest might be

several thousand. The access to machines might be harder. While 3D printers might be small and affordable for most of us, the bigger CNC-routers might cost hundreds of thousands, and be so large that it is impossible to fit them into any "normal" space. But, there is everything between these, and nowadays many of the available machines are at makerspaces, schools, and other co-working/comunal spaces. Then, of course, some private entrepreneurs use these machines as part of their business.

For this project, Bang & Olufsen provided me access to makerspace - fablab called Underbroen where I could find all the mentioned digitally controlled machines.



CHAPTER 3: Bigger picture - Why?

In this chapter, I will draw bigger picture why we need to reconsider our design practice, manufacturing methods and attitude towards consumption. I will explain origins of sustainability, current state and possible directions towards sustainable product design. The theory might be a bit abstract and general, but I will narrow it down in the end towards the concrete actions that we must take.

3.1 Sustainability

Sustainability as a concept has multiple interpretations and is taking steps in different directions. That is very understandable when such a topic is explored more, and new definitions and pathways might have been found. The same happened to a concept of `design.` Therefore I feel important to clarify a bit about what does `sustainability` mean.

We, as humans tend to seek comfortable and culturally acceptable life. That might mean, well-being, consumption patterns, wealth and social acceptance. We have our models where we have born and which we quite naturally start following when we grow up. For human it is hard to adopt the idea that lifestyle we live would be taken away from us. We naturally try to sustain the lifestyle we live, and when we feel our aspirations are endangered, we try to fix it, one way or another. Therefore sustainability means the idea we adapt to sustain our lifestyle, whatever it might be. It can be sustainability in social, economic and material matters. (Ehrenfeld, R. 2013)

The term sustainability can be seen in different lights, we can see it as a sustainable growth, which means that, e.g., business grows without warning its future. We can see it as consuming sustainably without compromising our consuming in the future. We can see it as design products sustainably without compromising designing products in the future. We can see it as acting socially sustainably without compromising our community. Sustainability has many faces which affect different things in our lives. In this thesis, the sustainable topics refer mostly to actions that we must take in creating more sustainable product design practice and distribution model. If, we extend the latter idea, designing for local manufacturing might improve the social sustainability, and in the end, local business as well.



Photo: Tuomas Tamminen

3.2 Needs for change

Historical background

During the history of human beings, we have been dependent on manual labor, and we have been living with what world had to provide for us. Our lives were tied in one place, and whatever actions we took, we were able to see the impacts immediately and on-site. Since those early days, humans have made gains and inventions for helping in our daily tasks. Eventually, this has led to the situation where we can control our environment more efficiently. We can produce energy, extract raw material, produce food, transport goods, manufacture products, and so on. Nowadays we call it consumption, which has led to over-consumption.

The current consumption model has got its birth during the industrial revolution in the mid-1800`s. Scientists managed to do scientific breakthroughs and technology improved rapidly. Humans started thinking that we actually can build a better future and this thinking was only fuel for the development of technology.

The revolution planted a seed for capitalist markets which started to grow fast. The markets purpose was to make more money for its owners by selling goods. One distinctive character of capitalism is that usually all the profits were invested to produce more goods to be consumed. Today marketing efforts are encouraging people to buy new products, and that has led to built-in obsolescence. It means that we manufacture a lot more than we use. Long time we lived in a faith that we can "manufacture" better future for us and the environment can stand that.

» Aluminum anodizing plant in the B & O Struer factory

Later on, the development has shown us that the future we created is not as sure as we would have thought. We already see the social injustice and consequences of the usage of natural resources.

According to Walker, S, and Giard, J. social justice and sustainable use of natural resources are the two main pillars of sustainability, *"...and major factors in any comprehensive understanding of design for sustainability."* (Walker, S., Giard, J. 2013).

“Industrial production has fostered vast distances between the sources of products and their users, with often disastrous social and environmental consequences. Designers and engineers usually work far from the factory or the sales floor; and many products can be overly generic, complex, harmful to people or the environment.” (Bonanni, L., Parkes, A., Ishii, H. 2008)

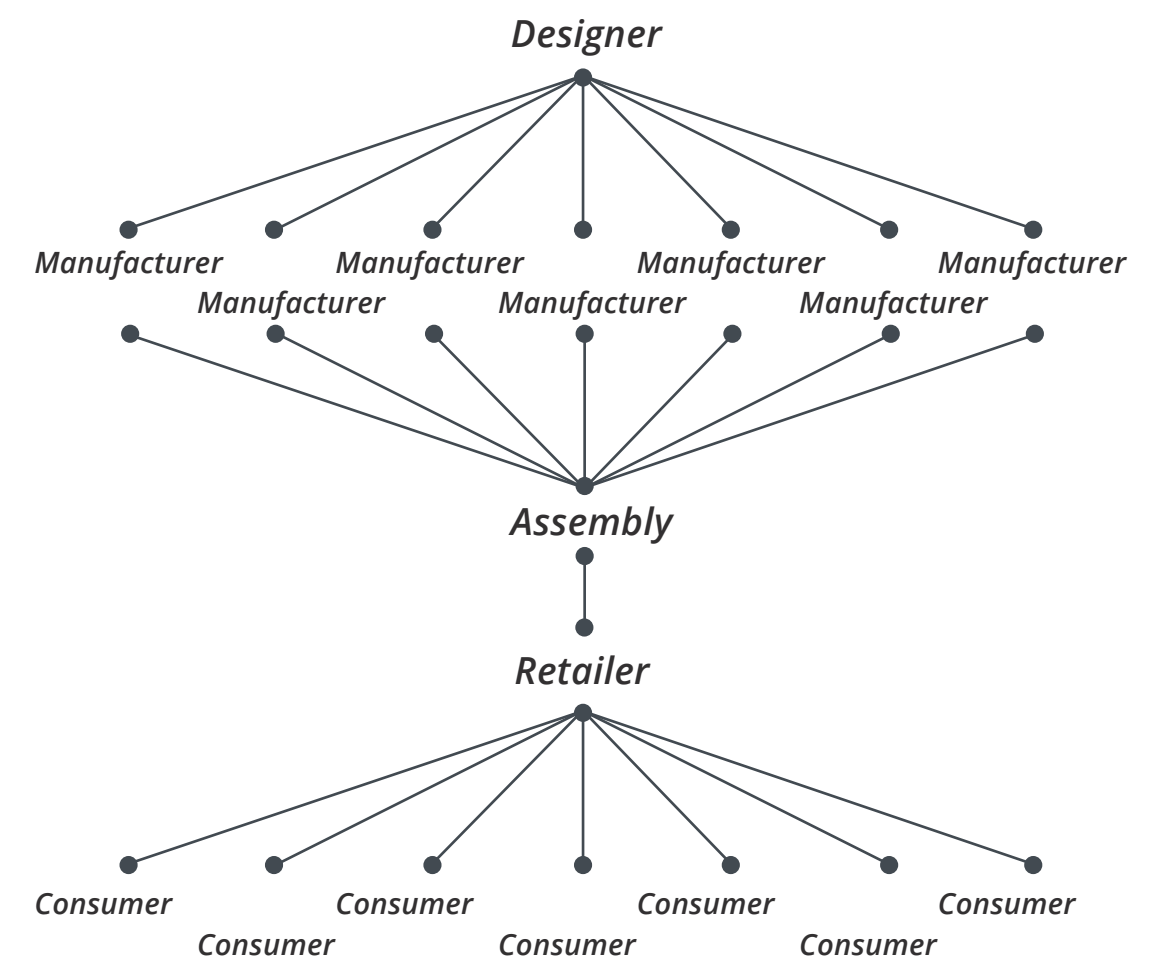
Current state

For every action, there is usually counteraction as well. Our need for sustainability is a counter action for our needs for consumption. There is plenty of paths that designers and manufacturers have adopted to provide more eco-friendly products. Paths like eco-design, zero-waste design and, cradle-to-cradle, are quite common. Some of them are purely marketing actions, but some of them do their job in creating better products.

In according to Janis Birkeland in this race of sustainability, there are two competing paradigms. The technocratic and green, which can be called hard and soft lanes towards sustainability. Technocratic lane pursues more efficient production methods to produce more. Green lane instead pursues slowing down the consumption. Anyhow, both lanes are aiming for the same result, but with different tools. (Birkeland, J. 2013).

Birkeland also says that *“Most sustainable development disciplines now accept that we must do more good and less bad through eco-efficiency and/or regeneration.”* Whether it is hard or soft, currently it requires a lot of questioning our current models. That is something that can be seen at the moment in the design field. Multiple new small practices are emerging in the field of material research, and bigger companies are testing new models in providing products for customers. We are at the point where we are trying to find the way to cut the corner and make a change.

Current problems in the sustainability context of product design are mainly related to the manufacturing chains and raw material extraction, which both are leading to social injustice in the end.



» Centralized distribution model.

3.3 Design for sustainability

Next, I will propose what sustainability might mean in design framework, as sustainability can be seen differently from a different point of views. In the recent years we have seen a lot of different mantras for sustainable design; reduce, reuse, recycle. A.I.R (Avoid, Intercept, Redesign) by Parley For The Oceans, and many many more. All the different strategies first have to identify the unwanted consequence and afterward the actions to avoid them. So, based on what Doordan, D. states about design for sustainability theory, our efforts towards sustainability are based on predictions what might happen if we don't act. (Doordan, D.P., 2013)

In the same paper the author provides a couple of different models how can we identify the points where the actions should be targeted. For example, the planetary boundaries explain briefly nine biophysical systems or processes that happen as a consequence of our actions. These systems are climate change, a rate of biodiversity loss, interference with the nitrogen and phosphorus cycles, ozone depletion, ocean acidification, freshwater and land use patterns, atmospheric aerosol loading and chemical pollution. (Doordan, D.P., 2013) Pointing out the actual consequences might help us to think where should we target our sustainable actions. Of course, the birth mechanisms of the consequences are so complex that it is hard to focus our efforts on anything specific.

One widely used design process for assessing the consequences is LCA, Lifecycle analysis which looks into every step of the process from raw material extraction to the disposal of the product. The model tries to optimize every level concerning the steps load on the environment. As Doordan states, the model provides provocative *"counter-model to the economic and legal understanding of designed artifacts as property."* (Doordan, D.P., 2013) Of course, this model still ends with a result which does not solve

any environmental problem; it only reduces the impact.

We are living in the system which Doordan calls Techno-Sphere. It consists of natural and technological metabolisms, which need to live in symbiosis. It simply means that we, designers are playing with "nutrients" of these two metabolisms that we have to organize so that they will not cause unnecessary harm. Every action we do is part of something larger, and it has its effect on something else. There is no stand-alone objects or artifacts in this world.

What must be noted from these subjects is that none of these provide any perfect solution. They are just theories which are trying to help and guide us designers into the right paths in this system. Therefore design for sustainability needs systematic thinking that takes into account many different aspects of the designed object.

"The future can't be predicted, but it can be envisioned and brought lovingly into being. Systems can't be controlled, but they can be designed and redesigned." (Meadows, D. 2008)

3.4 Change in practice

The previous, design for sustainability offered us an overview of what directions we might take to think more sustainably. But, if the theory is wanted to be taken into design practice, we need to define what are the concrete actions. There are almost as many approaches to design processes as there are practitioners in the field of design. In this chapter, I will introduce four approaches for more sustainable design.

Bhamra, T., Hernandez, R., and Mawle, R. are introducing four approaches in their article in The Handbook of design for sustainability. The more incremental approaches are product improvements and redesign while more radical are new concepts and system innovations. The approaches all work a bit differently and require different strategic and organizational actions.

1. Improvements pursue of making smaller modifications for products to gain more sustainable products. According to Bhamra, T., Hernandez, R. and Mawle, R., it might mean configuring the

product to meet legislation or other regulations. Or it can mean changes in production and material selection. Often these small changes might cause significant impact over time or, even create change in behavior. The downside, of course, is that just by improving product rarely solves the problem if the product by its nature is very unsustainable.

(Bhamra, T., Hernandez, R., Mawle, R. 2013).

2. A redesign is a more holistic approach to improving a product. It takes into account every step from raw material extraction to disposal and everything between them. Therefore it is crucial to know all the resources which are used during the journey of the product. LCA's (Life cycle assessment) are often used to assess the products life-cycle. There is plenty of different LCA's, and

their systematic approaches provide a very powerful tool for the redesign. The essential parts that often reduce footprints significantly are manufacturing methods, transportation and packaging. Reducing from these areas, usually also cuts in costs and makes the product financially more beneficial and more sustainable. (Bhamra, T., Hernandez, R., Mawle, R. 2013).

3. New concepts are more radical and influential strategy for sustainability. Often creating new concepts require a lot more understanding of peoples needs, culture, technology, and therefore multidisciplinary teams are usually formed for these processes. New concepts strive to change our habits or propose something that is needed for more sustainable living. (Bhamra, T., Hernandez, R., Mawle, R. 2013).

4. System innovation is, from these four approaches the most difficult, uncertain but, most potential when succeeds. It requires a strategic change from the organizational level and participation from different stakeholders. The system innovation is a holistic view which seeks to create a new lifestyle, production and consumption patterns, without rebound. The difficulty is to integrate products, services, economics and cultural aspect into a new system. One of the latest breakthroughs in this field is PSS (Product-service systems), where products and services are integrated so that they would create a sustainable continuation. In the end, the authors state that while innovations might cause more significant impact, is rarely easy to succeed in creating these systems. At the same time when success hits, the reward is more prominent than in incremental developments. (Bhamra, T., Hernandez, R., Mawle, R. 2013).

3.5 On my way to sustainability

As CREATE's mission suggests, we have to be open, inspire and be inspired to gain new knowledge. B & O CREATE is leveraging new local communities, who are utilizing emerging technologies and openness for creating innovations. Therefore it is meaningful to explore what open-design and local manufacturing could do for product design. To summarize open-design and local manufacturing for sustainability, I use Jeremy Bonvoisin's paper: Implications of open source design for sustainability (2016). The paper is a study how open design and local manufacturing could support sustainability. He states the same what I have noticed that the field lacks the number of studies, but with his research, he draw some directions for further research, which I introduce later.

I also feel necessary to specify the approach to the design process according to the four approaches which I introduced earlier. My thesis' framework by Verganti already suggest a radical innovation, and therefore it is a good match with the proposed 'system innovation' strategy for sustainability. Open-design and local manufacturing are offering new opportunities and playground for concepts and business models. We have already seen success stories in the world that have utilized openness and locality for creating products and businesses. On top of that, sharing projects are more likely to cause rebound for the company, concerning new ideas and therefore sustainable growth.

In this thesis actions towards sustainability refers to manufacturing methods and openness and the manufacturing system around it. Within the open manufacturing system, we can design products to create more sustainable future. Therefore I choose to follow the approach of systemic innovation and play within the boundaries of that and open-design, local manufacturing.

Open design for sustainability

As open design suggests, the openness means that anyone can develop and customize the product to fit in one's life. So, as Bonvois suggests, a design might get better due to a higher amount of knowledge. Faster adoption of technologies might cause more rapid innovations for companies, which in the end, might reduce R&D costs. (Bonvoisin, J. 2016). Bonvois' is referring to the latter to opening the innovation process, which creates sustainable development in the longer term.

As the general rules about design for openness suggest, the design should be replicable and repairable all over the world. Therefore, according to Bonvois it causes shorter *"...transportation loops, adaptation to the local ecosystem and even closed-loop material circles."* (Bonvoisin, J. 2016). And, on the other hand, open design tends to gather people in certain places like fab labs and urban manufacturing sites, and therefore empower local communities and improve social sustainability.

Local manufacturing for sustainability

Local manufacturing is mainly made possible by the development and affordable manufacturing methods, such CNC-routers, etc. That means we can use locally sourced materials on-site and we don't have to ship them anywhere for processing. Materials found locally can be anything from recycled materials, materials from a nearby forest or local material manufacturer. In any case, using them is a concrete action towards sustainability.

Another factor is the possibility to easily customize products, which could be connected to Bonvoisin's adaptation to the local ecosystem. That means products will not be manufactured to stock, but only on-demand, which might reduce waste and cause long-lasting products. According

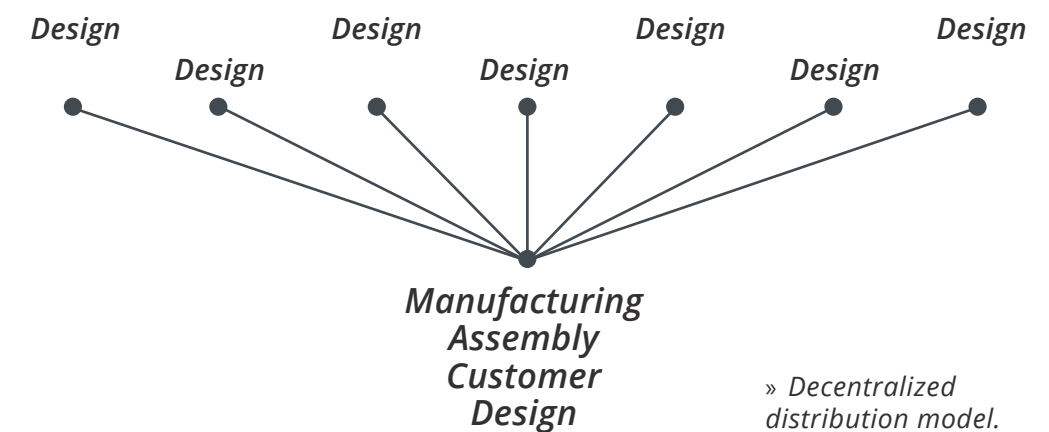
to Bonvois over-engineering is also avoided by better adaptation. As far as I understand that, it means that whenever the product is modified to serve in a certain way, it reduces parts because it does not have to be fitting for every occasion and be universal.

In the end, he states that open-design generates locally-bound value creation chains and environmental advantages in the form of emotional attachment between products and users or even manufacturers. Bonvoisin, J. (2016)

Therefore I should be focusing on designing a product which is accessible, simple, try to avoid over-engineering and take into consideration what kind of local materials I could use.

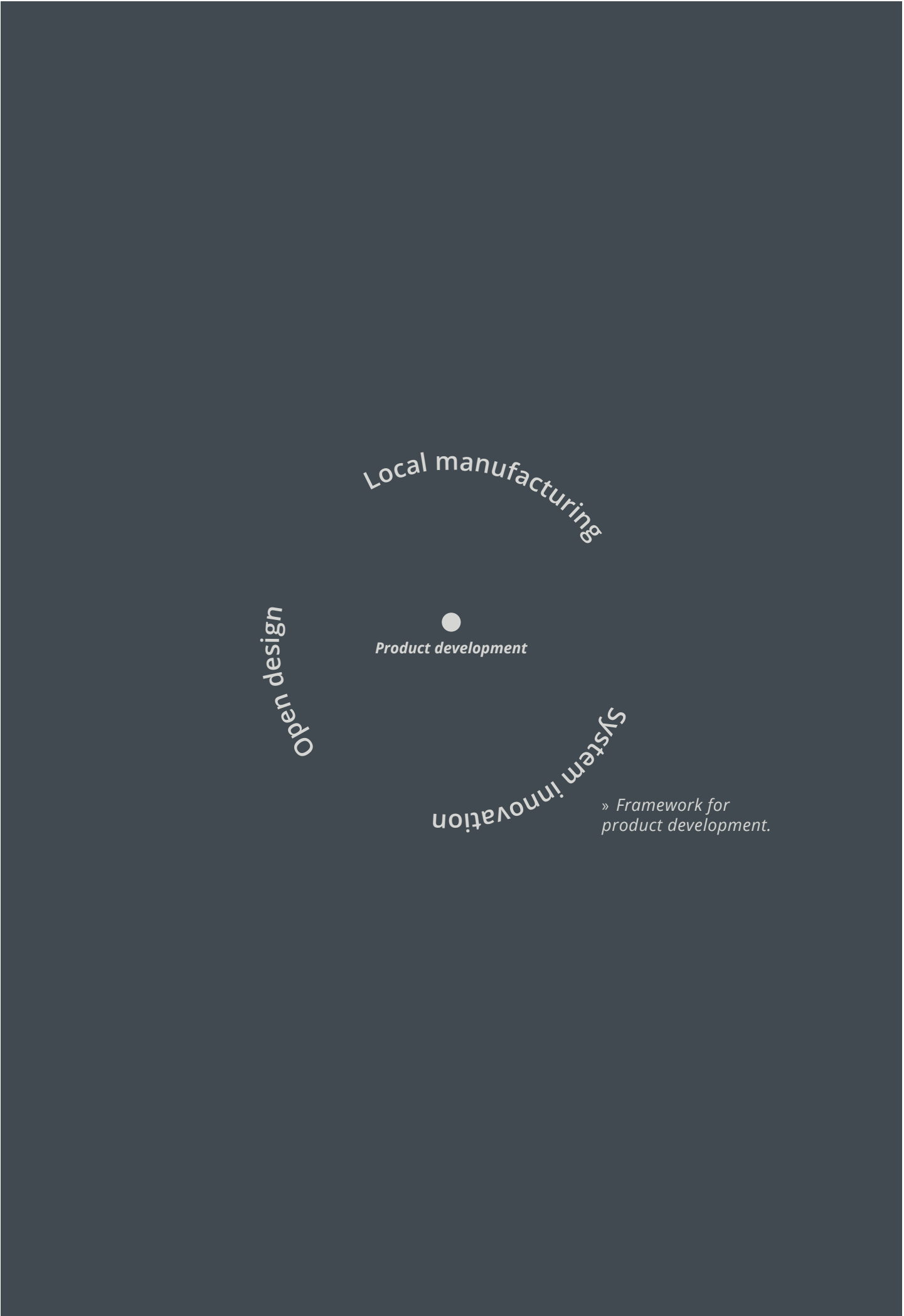
Open design + local manufacturing + system innovation = ?

Pulling the strategy of systemic innovation together with open design and local manufacturing, they should work as a new ecosystem for the product development. So what kind of product open-design and local manufacturing could produce? How would that product fit into a decentralized manufacturing system? Concluding the aspects, open design provides us the opportunity to share designs and manufacture products without complicated copyrights. Designing for local manufacturing instead makes it possible to manufacture products anywhere, only for demand. Combination of these two breaks the existing distribution and manufacturing model and gives us the opportunity to rethink the product.



CHAPTER 4: Case:
Open loudspeaker

The next chapter describes the product development process. First, I introduce the ecosystem of open design and local manufacturing. Then I explain the departure points, concept prototyping and, finally, I reveal the product.



4.1 The ecosystem of open design & local manufacturing

To gain knowledge from existing open, decentralized manufacturing systems, I will look into a couple of companies how they have done it and followed the principles of open design and local manufacturing. As speakers, in this case, are domestic, I chose two open-design manufacturers whose business is related to the domestic environment. The first is furniture manufacturer and the other works in architectural practice. Another reason why I chose these is that decades ago speakers were combined with furniture, but also home integration has been there for a while.

I think it would be interesting to find some synergies between different products, which are playing in the same field. Combining them would most probably be more desirable and meaningful to make than just an open standalone speaker. In a longer-term and broader perspective, it is vital to consider combining systems to find a new reality. That means also seeking new ways to do business with cutting-edge manners.

Open-desk

The open desk is British furniture company which has decentralized its manufacturing but also opened the blueprints for anyone interested. They have successfully turned their distribution model into a business as well. The open desk is collaborating with corporates to seek new possibilities of building our environment more sustainably.

Material: Flat sheet materials, mostly plywood, but also recycled plastic

Material source: Locally sourced timber

Manufacturing method: CNC for cutting

Customization: They have developed a system/algorithm which allows a user to decide the size of products.

Business model: They are selling the interior designs for corporates to make a profit. The local manufacturer gets paid if somebody/corporate orders the furniture from them, but a small amount goes to Open desk as well. They are still providing their blueprints for free to individuals for manufacturing themselves.



Photos: opendesk.cc



» Open desk's locally manufactured products.

Wiki house

Wikihouse is developing locally manufacturable housing solutions to find easy and fast way build houses. They are continually improving structural solutions to solve architectural problems. They are not making money out of it but offering new solutions for builders and contractors.

Material: Architectural elements assembled from flat sheets

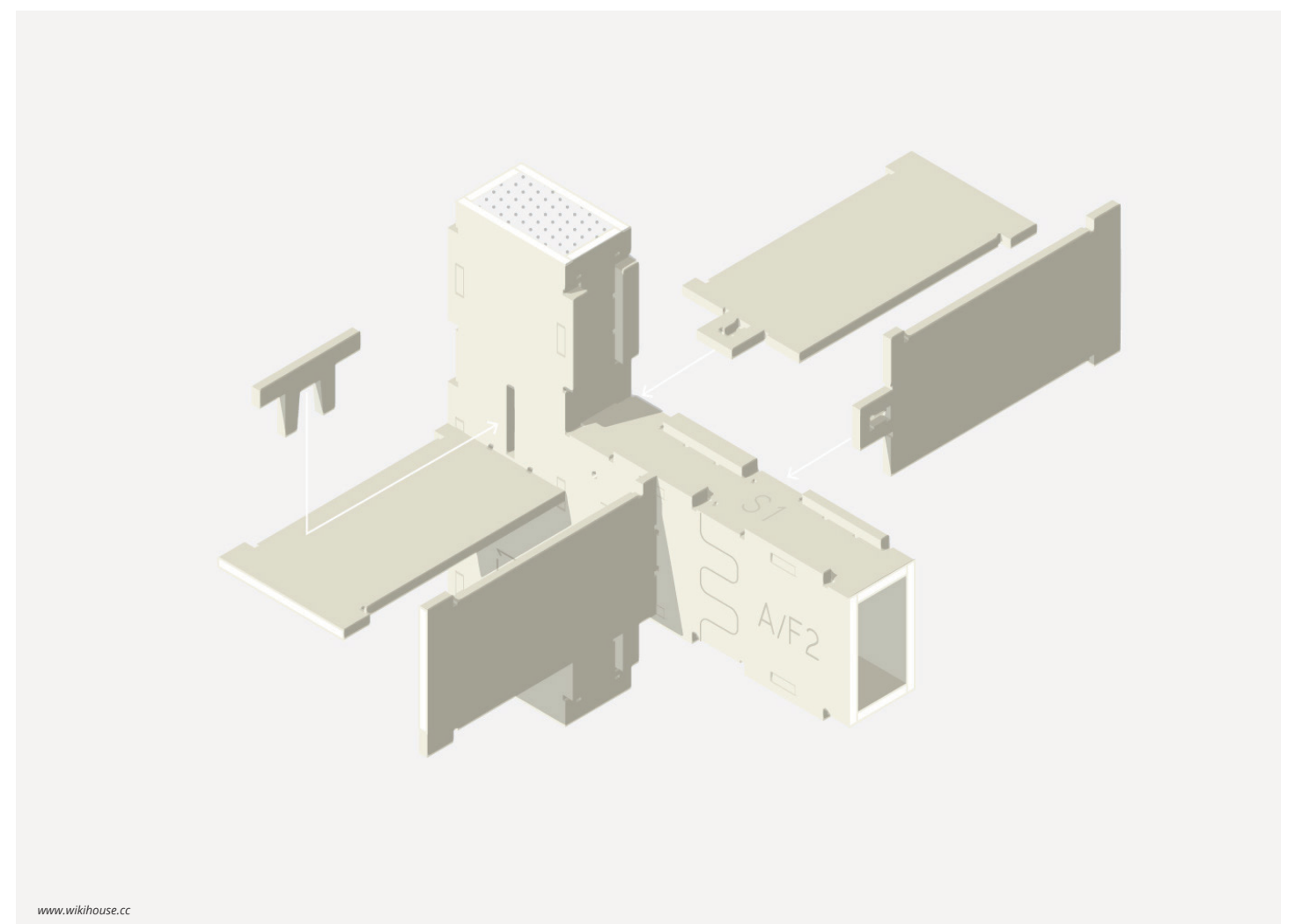
Material source: Locally sourced timber

Manufacturing method: CNC for cutting

Customization: The houses and their functionalities can be customized

Business model: Wiki house is a foundation and therefore doesn't make a profit. Everything is open, but builders, contractors, etc. are paid by the person who wants a house.

» Wikihouse in the making and joinery they use.



www.wikihouse.cc

Designing for local manufacturing and openness

If we look at the products of the Open desk and Wiki house, both are using universal materials. The way how different parts are assembled, is based on simple connections and is done without complex forms. The simplicity is a consequence of the requirement of replicability. The both have defined a one production method instead of several tools. That decision arguably makes the production more streamlined.

The business model they are using, allows skilled people to use the blueprints and manufacture the product for themselves. I guess that is also because, at least in Wikihouses case, that they want people to develop the system further. In case of Open desk it looks a bit more like branding action, because it seems that they have not designed the products to be developed.

In both cases the business potential is, if the company offers something else on the side of the open blueprints. For example help in designing entireties or connecting different parties to execute the subject of design. Therefore in the product development, I am aiming for a result where blueprints are open, but there would be a possibility for business as well.

I consider open-design as an action that people with a decent skill set and access to local workshop could do. That has naturally led to a practice where products are relatively simple. The problem is that simplicity is relative. Complexity and simplicity are not the same to all of us, because of our different skill sets and work environments.

The design and blueprints are usually created with basic software which is available for the masses. Openness in design does not mean open, public and shared blueprints. Open-design requires a specific type of approach for design and making sure that the product really would be ac-

cessible almost everywhere without friction and unnecessary complexity. Anyhow there are some principles which I will introduce here.

My thesis subject is not to define the definitions what is open design, and therefore I looked existing principles for open design. The following principles seem broad and abstract, but I guess they are made for universal guidelines and not to specify concrete actions.

The following is from the website called: open-making.is, which is discussion platform hosted by Opendesk and Vitra design museum.

“Design for opening processes and organizations

Open Making can democratize not only the design and manufacturing of artifacts but also the design of processes and organizations, which should also be documented, visualized and shared. Designing, sharing and manufacturing collaboratively can enable us to learn how to build global and local networks that are more sustainable thanks to the fact that anybody could improve them. Building a new economy is not an easy task, but it's easier if we test it in a distributed way and share the results. Designing and making together can enable us to learn the social, political and economic dimensions of Design and Manufacturing.”
–Massimo Menichinelli

“Global ideas in local contexts

A global production system composed of many nodes yet not subject to the rules of mass-production provides new opportunities for social and economic development. This emerging model has many positive qualities: from the sustainability of producing locally to meet real needs, the possibility of imagining, crea-

ting and working all over the world with both equal opportunity and equal access, and the possibility for everyone to see their own ideas realised.

As Enzo Mari once said: “Everyone should design: after all, it is the best way to avoid being designed.”
–Silvia Gasparotto

“Design for Disposability

Objects should be able to be recycled, reused, repurposed, or otherwise sustainably disposed of.”

“Design for Repairability

Objects should be built with fasteners, methods, and materials that are easily removed, replaced, repaired, and/or substituted for.” -Will Holman

“Design for Sharing

Making a project as open as possible means making its documentation as accessible as possible. An object's technical drawings, assembly instructions, and process documentation should be available free online.” -Will Holman & Bram Geenen

“Design for Accessible Materials

An object should be built with fasteners, methods, and materials that are as broadly accessible to the world population as possible.” -Will Holman

“Design and make like you give a shit

Material use has consequences, some materials are finite resources and even using renewables has an

impact. Consider how your design will create waste, how long it will last, the emotional connection that the custodian (better than customer) will have with it and how the materials it is made from could be recaptured for future use. As a designer and maker you operate within a complex web of interconnecting systems and the choices you make ripple far beyond your immediate horizons. Giving a shit about this is the first step in doing something about it.”

“Design for Editability

An object's design should be downloadable in a free, open, and editable file and further iteration encouraged.” -Will Holman www.open-making.is

Executing the principles

The most important principles regarding my project are the “global ideas in local contexts,” “design for accessible materials” and “design for sharing.”

From the design point of view, it means taking into consideration what are the global materials, what are the universal practices in local manufacturing and, what concrete design actions we do so that we can share the designs. I think right principle would be that, everything I design, should be done so that the maker does not have to be trained manufacturing professional to understand how to make the product.

System and stakeholders

As my approach is leaning on designing a product which could be working in a decentralized manufacturing system, I need to explain the possible system and its stakeholders more carefully. Therefore I will here describe the system and how different stakeholders might act within the system. I found Open desks and Wiki houses model feasible, and they are already proven to work. Therefore I will be using them as a reference. As noted before, there are no strict barriers, and that is the crucial point in distributed manufacturing.

Develop and manufacture if you can and always share it -that could be the slogan.

Bang & Olufsen / CREATE

The mother company itself is the learner and provider in this project. It offers the facilities and knowledge that they have. Its role is more about managing B & O CREATE and its resources considering cutting-edge projects which don't have immediate economic value. What Bang & Olufsen hopes to get back is new and fresh ideas about the future of speaker manufacturing and business possibilities. CREATE works as the platform where the development happens. As a part of my thesis, I will compile the whole project so that it can be published in the CREATES networks and shared with other interested parties. CREATE is also the channel from where the new information goes into the mother company. That is the purpose of the CREATE, to feed the innovation.

B & O CREATE also provides, together with Hifiberry, the 4-channel amplifier which is the core of the project. CREATE partly does the software maintenance, but hopefully, the new applications would also come from the open-source community.

Open-source / design community

The community means the makers, users and other possible parties who are interested in experiencing with the product. They are the primary focus group of my work, as they might act as the manufacturers, designers, and end-users of the product.

Makers

Makers are the people who would manufacture the product for themselves, for somebody else or just for the sake of experimenting with the product.

I feel that they are the group that I have to take into account the most when designing the construction. End users don't care about the structure as it is not essential anymore in using the product. The product should be simple enough to be desirable to build, but still sophisticated enough to provide some satisfaction. As I consider myself a designer-maker of the product I feel that the product should be mentally stimulating to manufacture, not too difficult nor too easy, but the line between them is like a line drawn into the water.

My responsibility is to design a product which works in the system. Being a maker myself ensures that I have the first-hand experience what it feels and takes to manufacture the open design product. Therefore I will be reflecting my feeling about the manufacturing process as carefully as I can.

Users

The open-design community, users, and makers are a bit blurry group as they may be the same people. I propose roles for different actors here. What if the end user is more like a customer who gets the product from the maker who acts in the open community. But what is the role of the customer? As we have discussed here, local manufacturing could make customization easy. A customer might be a person who makes decisions about the customization. As an end customer, they also might have the possibility to repair, update, and end disposal the product. From the user point of view, I need to consider the use-cases and needs from the product. That is why I have to conduct user study as well, and not only concentrate on the manufacturing aspects.





4.2 Setting the ground for the concept

What I will be doing is an open-design loudspeaker which follows the open design principles. To contribute to more sustainable product design, the design will be aiming at creating a product which would work in an emerging system and different stakeholders.

I will keep in my mind the already existing systems and consider them as good references of the working systems. Note that, this is still product design thesis, but I keep the possibility for business in mind. The locality, digital tools, and open design are only enablers of the new kind of product and not absolute values.

"Firms that develop design-driven innovations step back from users and take a broader perspective. They explore how the context in which people live is evolving. Most of all, these firms envision how this context of life could change for the better. The word could is not incidental. These firms are not simply following existing trends. They are making proposals with which they will modify the context. Their question, therefore, is, "How could people give meaning to things in this evolving life context?" Verganti / www.designdriveninnovation.com/interpreters.html

In latter citation, Verganti explains how and from where the ideas to inform the design comes from. He states that companies should use different informants to find new meanings to products and generate new proposals. As I am following the process of DDI loosely, I here clarify what kind of sources I am using to probe the product possibilities.

I have already explained how open design and local manufacturing could contribute to sustainability and concrete actions towards that. Then I have looked a couple of companies how they execute these actions in their practice and who are their stakeholders. Based on the learnings from

there I have described possible stakeholders involved in my project. The described actions and the case studies show that the products can be turned into a business, which means that there are interest and cultural space for open design and local manufacturing.

Next, I will be conducting a user study to find some insights and ideas from real users. They will be acting as informants for my product proposal. Later I will combine the results with my observations and research. As the context of manufacturing and openness is based on maker culture & environment, I will be using them as informants as well. Finally, combining the sustainable actions, case study, user study, technological opportunities as well as my experiments and research I will design a new concept.

Asking from people

Loudspeakers are for creating a sound, which is their number one functional purpose. But as our lives, apartments, musical preferences, etc. are so different from each other. Therefore I conducted a research to find the real needs and problems related to loudspeaker systems.

In the first part, I wanted to get a broader view what are the basic needs and problems with loudspeaker systems. In the second part, I went more specifically to my target group and tried to gain more profound insights into how they use speakers and what kind of speakers are needed.

Part 1: Questionnaire

In the questionnaire, I wanted to find out the reason for why people would or would not replace their existing systems. Asking about the replacing I tried to get to know the reasons for buying a new system. The survey was questionnaire with open answer possibilities. I got 55 answers in total, which is entirely enough to draw certain conclusions. The questionnaire was sent randomly selected people as I wanted to get a broad and universal answer to what are the basic needs from a loudspeaker system.

The most critical need was sound quality. That is a default. Other often-mentioned answers were: Easiness to connect with different sources, simplicity, and timelessness, movable and extendable, relatively small size and a possibility to repair. The results gathered were in the end quite obvious, but still, they proved my assumptions right, which was needed.

Often, speakers were considered to convey the sense of style and be part of the interior. For some people, speakers represented their lifestyle, status, and passion for music. When the participants

were asked about when they would buy new speakers, one common reason was if space/interior changed due to a moving to smaller/bigger apartment. People saw replacing also feasible idea if they needed more speakers to create a multiroom system. One clear answer was that if people wanted to get more sound from their speakers, they would replace them. Also if technological development has gone by and they needed to update/upgrade their system to meet new requirements.

Part 2: the User study

For the user study, I used qualitative methods as I believe that listening music and how we interact with musical instruments is a highly individual habit. We used a focus group to gather insights how they might be interacting with loudspeakers. There are varying opinions how many people is enough to gain some useful insights. According to Saldana *(Saldana et al. 2014)*, three to six persons provides already broader spectrum. Thinking of loudspeakers, what I learned from the first part of the user study is that the opinions quite homogenous in the end, so there is no need for a broader scope. The people for the survey we choose mainly according to our target group. We focused mostly on persons who probably would not be the manufacturers by themselves, but more like consumers. They are relatively young, 24-35 years persons who live in the city. There was one exception which was a bit older person, who was manager and owner of a local manufacturing facility. By interviewing him, we tried to gain knowledge how people who could make a loudspeaker thinks about open-design loudspeaker, and how it should be designed to be feasible to build.

Sessions & method

I arranged the sessions at peoples homes and in local workshop space. Questions asked were about listening habits and which kind of speakers would fit into that. With these questions, I tried to get insight if there would be a need for modularity in practice and in which cases there would be a need for a modular loudspeaker system. Another set of questions were about customization and what kind of loudspeaker would fit into one's homes. Finally, we asked if people would see it possible to buy a set of speakers from local production facilities.

To power up the discussion, we used simple boxes which represented speakers. The boxes didn't have any design in them. We asked people to play with them and show how they would set up the speakers. The discussion was first structured with relatively simple questions, and in the end, after revealing the concept, the talk was open for anything that is coming up.

Interpretation

The results from the sessions were in the end quite similar. People see speakers as functional objects where the aesthetic plays a decent role. One of the participants was more than just average music listener, and for him, aesthetic was seen less necessary than among the other participants. Customization of a loudspeaker was seen as a feasible option, but all the participants said that it has to be made comfortable. Generally, it seems that among the participants the speaker should blend into an interior and look "down-to-earth" or even be invisible.

The modularity was seen useful when situation changes and more sound needed. The study shows that modularity was seen possible by adding smaller speakers together rather than making one speaker bigger. One participant said that if there is modularity, it should be made so that the whole system is intentionally designed and avoid poor screw systems, which already exists.

How people placed, the speakers were quite conservative. The most common was to put the speaker on the wall or the shelf. When asked to put and play speakers, people mostly started building two point or home theater systems. One person stated that his television positioning dictates the positioning of the speaker. Interesting in these answers was that almost everybody wanted first quality sound, then invisible speakers and in the end nice looking speakers which blend into the interior.

We also asked how they would feel about buying a speaker from a local manufacturing facility; the idea evoked some interest. The participants were a bit hesitant if there would be too much effort. One participant also mentioned that for her that would add value to the product. She said that the transparency of the process is exciting and its kind of "what you see is what you get."

Other exciting ideas were an app where the customer could choose the materials and colors for the speaker. That idea could be applied to a worldwide open speaker design, where anyone could design speaker, then Bang & Olufsen validates the designs online, and local manufacturer produces the speaker for local markets.

Conclusion

The first study proved many of assumptions right but told me many things that I had not thought actually. We can say that people show interest towards a modular system, so they can upgrade and downgrade it when needed. But modular also in a sense that it can easily be repaired or updated if required.

We can say that most of the people do not want to have big speakers, but still, quality sound is desired. There must be a compromise done in that sense. As the speaker is also seen as a status symbol, in a world of overconsumption, I would assume that simple and long-lasting products are feasible in a domestic environment. People want to show that they care about the sound quality, but also excellence in design. The speaker should represent the sense of style and ideology of the customer.

In some answers, the look was lifted even further than the sound, but majority kept the look as a secondly important aspect. Speakers indeed divide opinions as people who were more than average into the music didn't care too much about the look, it was more about the sound. Still, the majority are not these "audiophiles." When people talked about the look, simplicity was the most common word. Others said that they don't want to see the speakers at all, but if they would have to, they should be seamlessly part of their interior.

To sum up the conclusion, people want to curate their lives, so they want to fit and adapt their speakers into that life. People see speakers, as functional objects were all the malfunctions, are seen very distracting. I assume it is because, it is only the sound and look that people want to interact with, not cords, connections or placements. It seems that the speakers do not get old (unless they broke), but the use cases changes which make the speakers obsolete. But what if the spea-

kers are part of the living environment and not something that can become obsolete?

Thoughts and observations

During the user study, I noticed that the usage of many boxes might have caused the ideas of multiroom systems. People did not think about using just one speaker, even on some occasions it might be a better option. But, also upgrading one speaker felt very strange. The reason might be because the concept of scalability is a very strange idea. Anyway, the general attitude was that there could be room for new and unseen solutions.

During the research process, I started also looking for my own needs and observing my home environment in the hope of getting some insights. I felt the same that many others in the survey, that I wanted speakers to be minimal as well so they wouldn't be too distractive in an interior. Another interesting thought that I share with some of the interviewees is that if it were possible, I wouldn't like to see the speakers at all.

When I was looking at my apartment, I realized that homes have quite a lot of "waste-space." For example, areas in the walls, where one can't fit shelves, artworks or anything. So could those areas naturally accommodate speakers? If we could customize the size locally to fit in the specific space, would they be part of the architecture or interior and not just add-on speakers? Could that also give us the opportunity to decide which size speaker would best fit into a particular space?

» User research at informants homes



4.3 Design process

The process was by no means linear, but more like going back and forth according to learning and getting new knowledge. In the design process, I will present the setup where I started working and main turning points which affected the result.

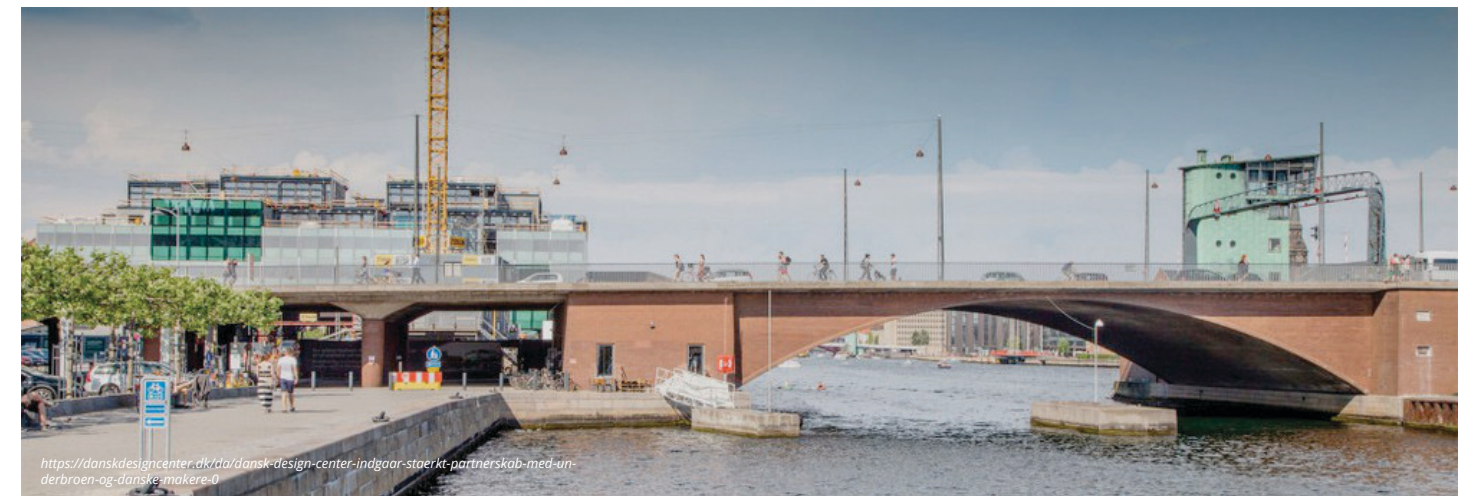
Departure points

The setup where I started to work with actual product development was quite exciting. I had access to a local maker space in the downtown of Copenhagen, where I ended up spending most of the time. But besides that, I visited a couple of times at Struer where I had a chance to discuss with product developers and acousticians. Sometimes I also visited Bang & Olufsen Copenhagen office at Lyngby, where they mostly have developers, marketing, and business people. I believe that all the places had some impact on my process, but most of all it was a steep learning curve for me, as I was unfamiliar with the corporate world and maker culture.

On a daily basis, I started to work at Underbroen, the makerspace. Underbroen offered a lot to me, but later on some challenges as well. The place inhabited some wood and metal work area, laser cutter, 3D-printers, and electronics table. But most importantly, an accessible CNC-router, which I could use as much as I wanted without assistance.

When I was about to start the actual product development I knew: what to take into consideration design-wise from the sustainability point of view. I knew that there was a cultural space for new kind of products and peoples perception towards loudspeakers inspired me. So, what I did not know was what kind of loudspeaker system I was about to design and why? That question was following me quite a long time.

UNDER BROEN



» Maker space called Underbroen is literally located under the bridge in the downtown Copenhagen.

Inspiration

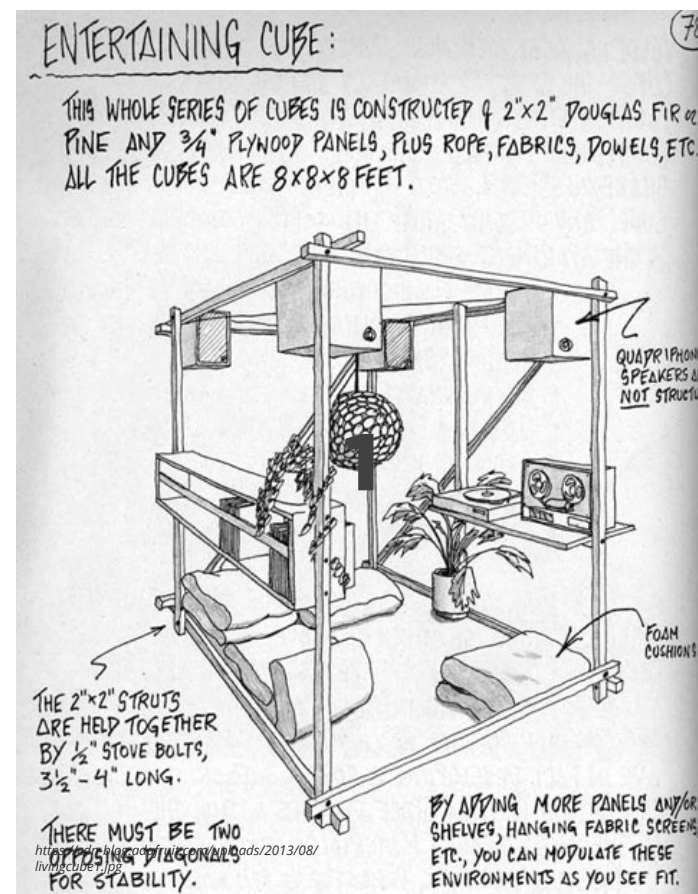
As we are playing in a world of local manufacturing, I looked into what else there is. I had found already Open Desk and Wikihouse -kind of solutions. Besides them, at the moment there is a lot of different sort of flat sheet products which has quite a unique appeal. They are very graphical, which I guess is a cause of the manufacturing methods. Besides the forms, I looked a lot into different applications where locally manufactured structures were used. I got interested in the furniture and architectural elements. Not only whole houses but also the add-on structures, interior walls and "houses inside houses." Hennessey and Papanek envisioned "living cubes" already in 1973. "Living cubes" are structures with speakers, built inside houses.

I tried to envision the environment where I wanted my product to live. I wanted the environment to reflect the simplicity and same kind of ideology that local manufacturing and open design represents. Therefore I chose environments which use a simple sheet and, other stock material as their raw material. For me, they represent something humble, but stylish. Adaptability and honesty. Honesty is something that I don't see in B & O's existing products, and therefore I saw an opportunity in there.

1. Modular living cubes, with all the necessities, including sound. The modules are designed to be built inside houses.

2. Sheet material used as an interior element. Here as shelves and hangers.

3. A house constructed from sheet materials.



Target group

The target group is the same which I used as a focus group for user study. They are the most potential customers who might adopt these kind niche products. The target group is something which helps me to focus on specific lifestyle and culture.

A person who knows what he/she wants and is open-minded for new products. He/she probably is conscious of sustainability regarding products. The customer is a perhaps young person who lives in the city. He/she is an individualist person and likes to express him/herself through products. He/she sees the potential of customization and is passionate about making a difference.

Drivers for the design

The basic tool for designing a product is defining drivers for the process. It means creating steering definitions, which makes it easier to head towards the wanted direction and fulfill the priority needs. I will not include sustainability in this list, because I feel that it is the default and all the others combined would lead to a sustainable product.

Construction – *The product should be easy to manufacture locally.*

Material – *It should be able to manufacture using local materials.*

Aesthetic – *This product should tell the story of how it has been made. The simplicity should blend into the surrounding environment.*

Open design – *The design should follow the principles of open design.*

» The BeoLab 90 is probably the opposite from its concept than my product. It has 18 drivers in total, and its cabinet is solid casted aluminum. BeoLab 90 wants to stand out from the environment, and it really shows how it is made.

Requirements of speaker

Designing loudspeakers is highly discussed topic, and it seems that there is not one right and straightforward answer to that. There are numerous different needs, use places, preferences, to name a few requirements from the speaker and we can not set up strict principles which makes the sound good.

First of all, big cabinet creates a big sound as the drivers can move more air and vice versa. But still there are several ways to compensate it, if the cabinet is small, digital signal processing can help us pump up the sound. The cabinet should be dampened, meaning no echoes inside the cabinet. An unechoing cabinet can be achieved by designing it with no parallel walls, or we can use dampening material for erasing the echoes.

Then, of course, we have drivers. The bigger driver, the bigger sound, but then again we should have a big cabinet as well. Speaker design is always about sum of its different parts, and every change has its effect on something else. I don't have even near expert knowledge of acoustics, and therefore I asked the acousticians for what we should concentrate on.

For this project, sound / acoustic engineer proposed us to use decent size drivers. The reason for that was that, as my purpose is to make open design speakers, the user should get a sense of good sound immediately without touching the DSP or other ways for tweaking the sound. They also proposed that I should instead go big or go home. Even though I started to understand the basics of speaker design, I didn't want to stick too much into it as I thought it might begin to affect the design process too much.



Flying high

The whole project started with sketching in a very early phase when I only knew little from open design and what it means. Therefore the first sketches and ideas were flying very high from the form point of view. From a designer point of view, it was more about poking different points in my head and trying figure out what could be the starting point. But that's how the process usually goes, one start from crazy stuff and, then end into a more conventional result. Later, the ideas developed along the way when I got more ground knowledge for the concept.

The prototyping happened all the way to the end, as I found that I could do quite fast iterations, because of the access to the CNC-router. On the other hand, it was bit misleading the process as I started to stick to small things, trying them and not developing the bigger idea.

Finding the right path

The process started learning how to use all the machines at Underbroen It was quite a lot about experimenting and getting to know the premises and people working there.

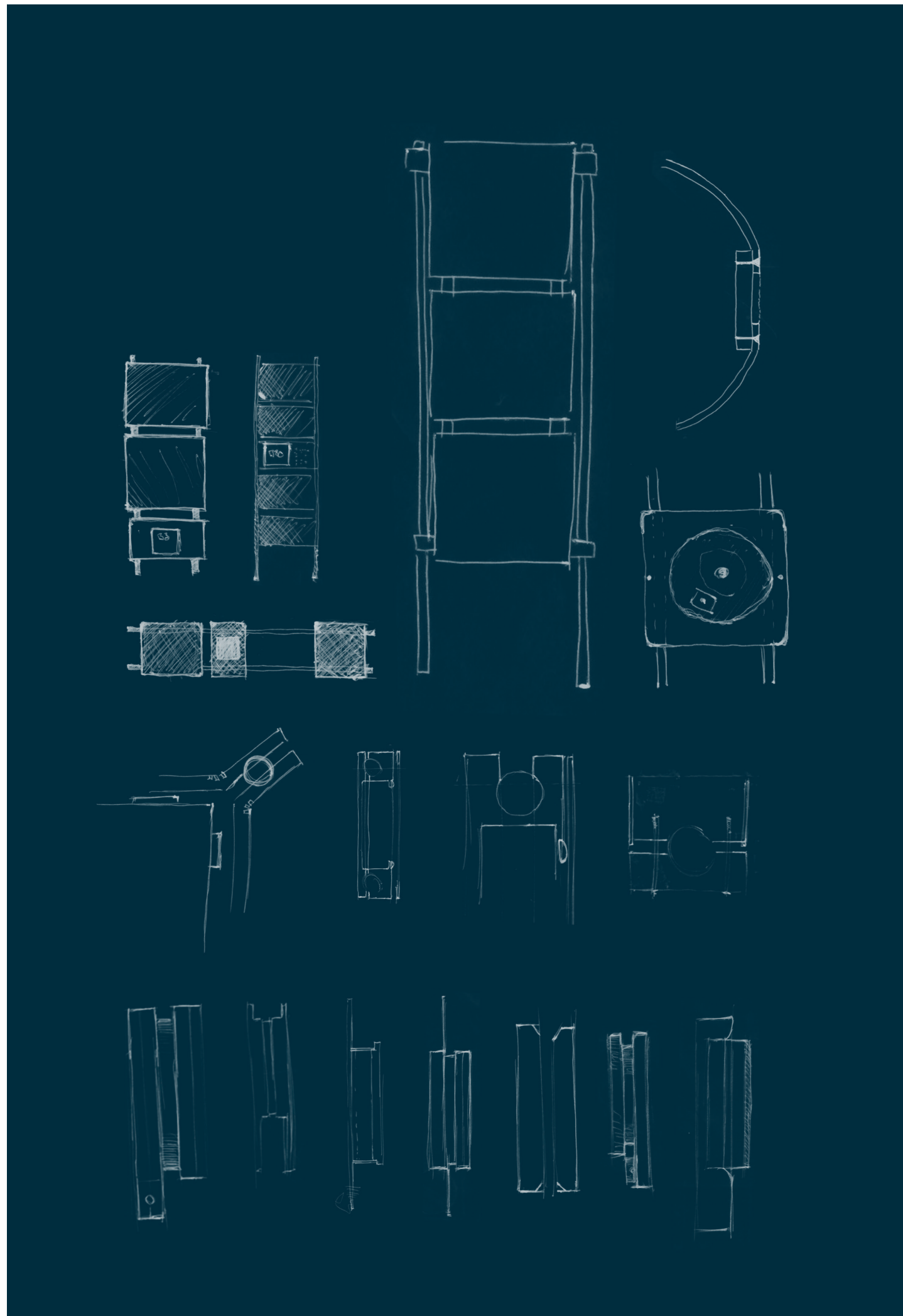
The available materials were mostly sheet material, mainly because maker spaces are using the standardized material. That is when I realized that, if I am designing a product for local manufacturing and openness, the material should be something that most local workshops use. Therefore I naturally started to stick only to flat sheet materials. Flat sheets are available globally, but they still provide a wide array of different materials from metals to wood and recycled plastic. For example, the British company called Smile plastics has started manufacturing sheets from recycled plastics.

During the process, the possibilities at Underbroen began to affect the process. Quite early I realized that the facilities didn't provide well-functioning wood and metal workshops. They had some machines, but often they were broke, or there was something else going on which caused inefficient prototyping possibilities. Considering CNC router as a production method would mean that the product should be designed in a way that suits the router and flat sheet material. It started to guide the process in the direction where I had to consider what are the design possibilities of using the flat sheets. And, more importantly, where is it purposeful and what is the use case.



Photo: Tuomas Härmäläinen

» Me using the Underbroen's CNC-router.



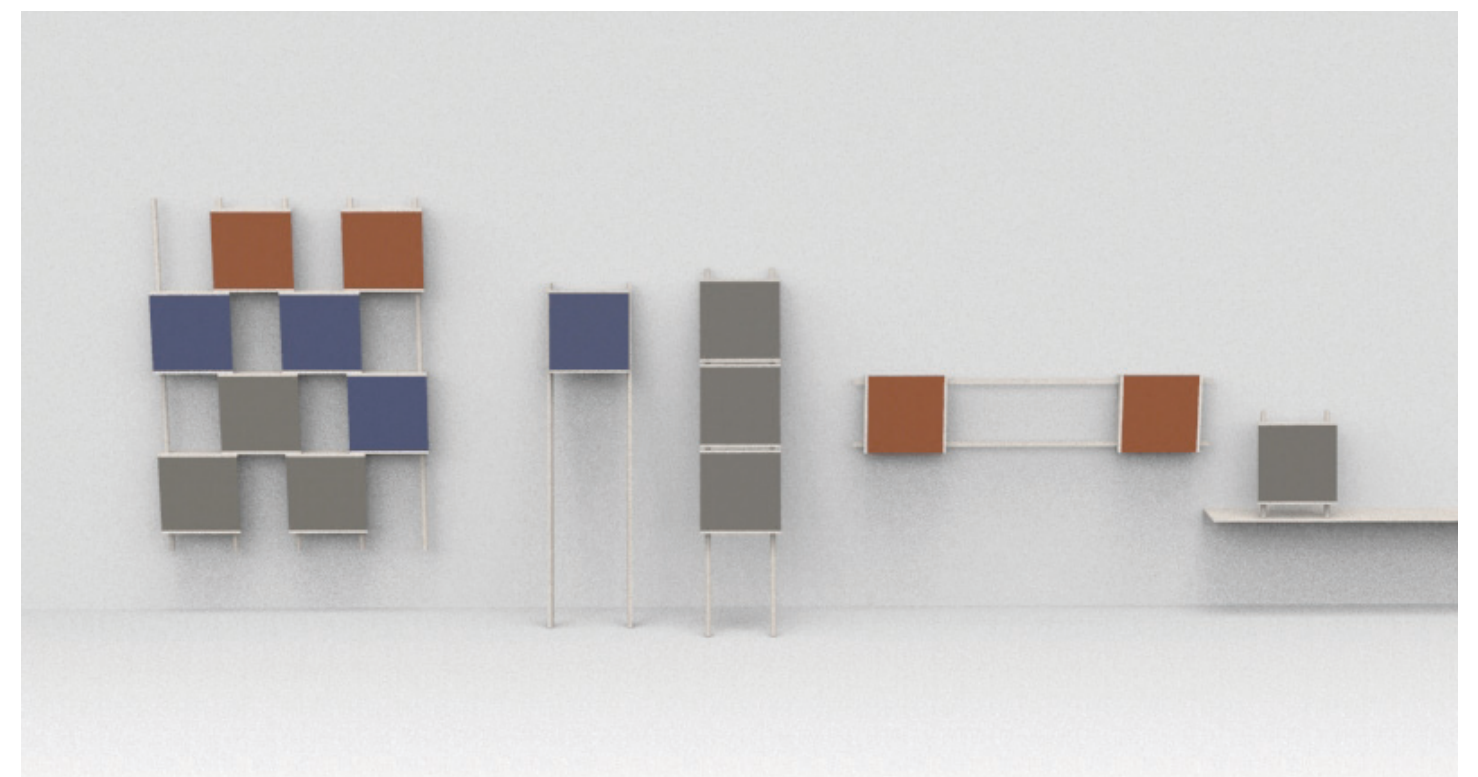
Modular concepts

The early phase was very much about looking different directions. Lots of modular thoughts were thrown up, as that would contribute to sustainability and add flexibility for different situations and use cases. Using modules people could always extend their products and get speaker tiles when needed and never without a cause. That would have been beneficial to openness as well because it would have provided people possibility to customize and develop their systems.

The first concept here was based on one design which the user could always multiply and add together with the specific attachment system. It would have allowed quite many use cases, from freestanding options to wall hanging systems.

The first ideas of modularity became quite fast questioned as the CREATE 4-CA amplifier has only four channels, meaning that we should daisy chain

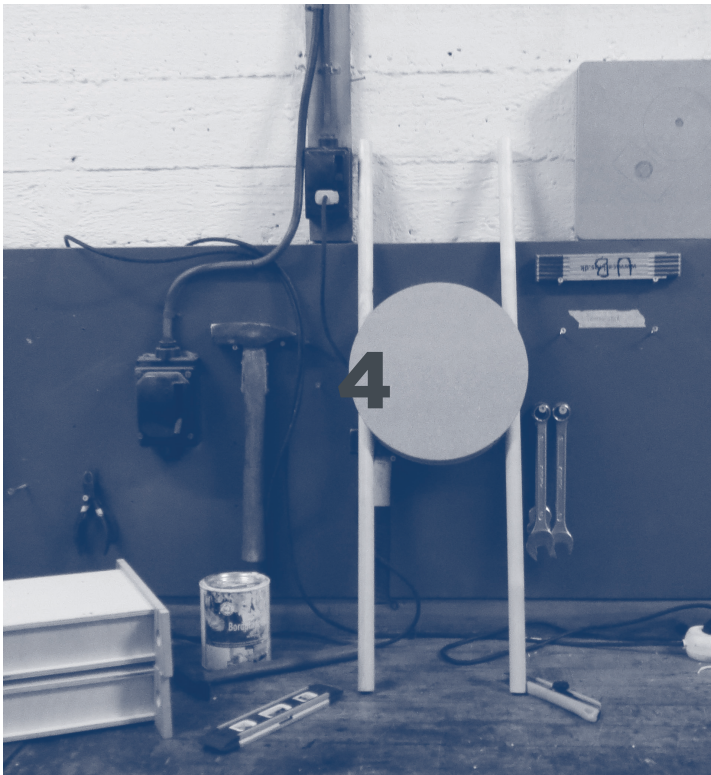
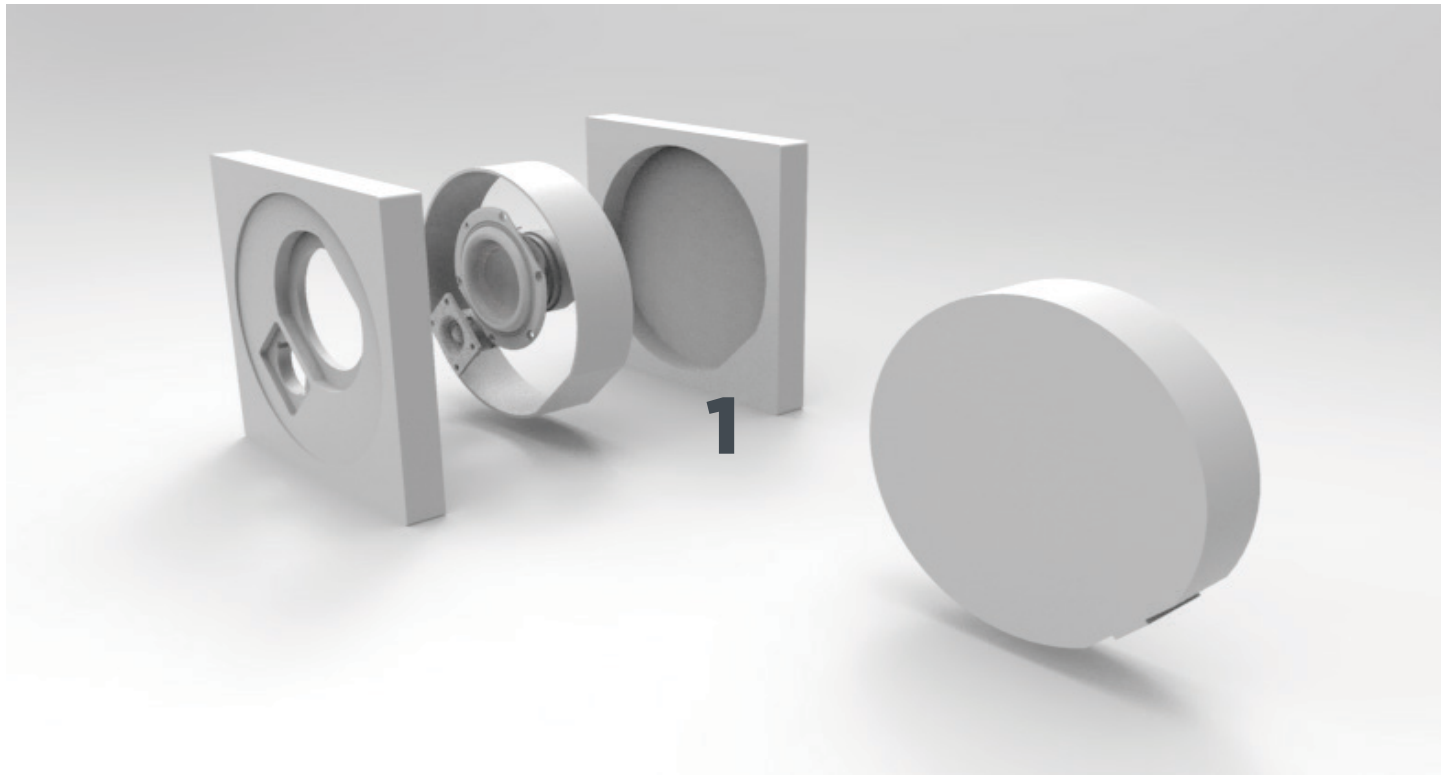
several amplifiers. That would have caused some more technical and software issues. Therefore we decided to focus on a system which uses maximum four channels, which means four drivers. The options for setup would then be two speakers with two drivers, one speaker with two, three or four drivers.

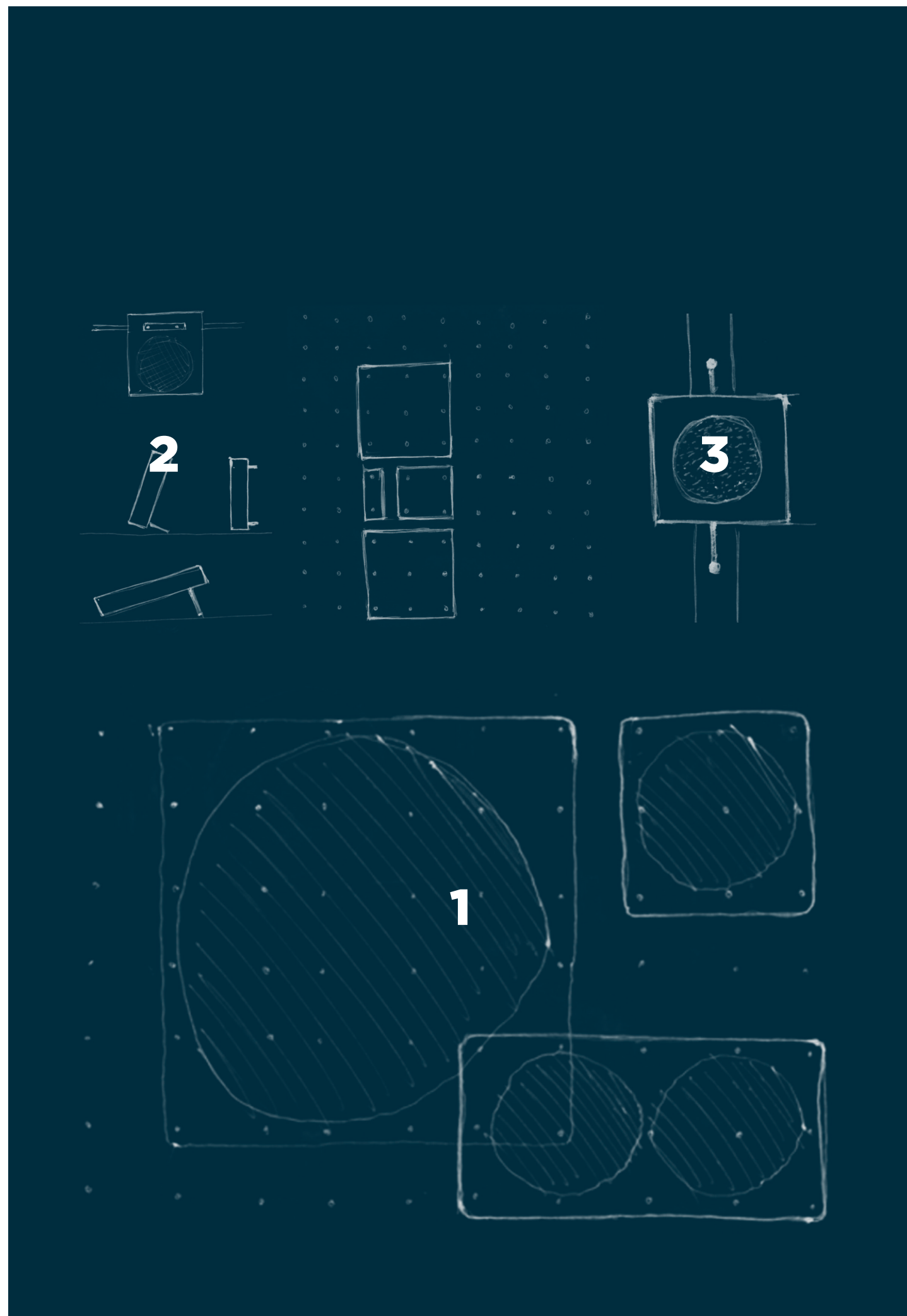


Prototyping the construction

The process went on naturally building several prototypes and learning how to use CNC router. The first prototypes were more like studies of construction and what kind of constraints there is in using the router. The construction was from the first days mainly based on three parts. Two layers made from flat sheets and aluminum in between them. From the early days, I wanted the speaker to be as thin as possible, which affected a lot to what ideas felt feasible and what not. The most defining aspect was the amount of space the drivers needed. The design of the speaker began rotating around the shape of the flat sheets and defining what would be the use case. We used a lot of MDF as it is relatively cheap, it has good acoustic qualities, and it is easy to work with.

- 1. A Rendering of the possible construction. It consisted from top & bottom parts, and aluminum ring between them. The tube is the mold for bending the aluminum.
- 2. I used wooden poles from hardware store to prototype the possible attachment systems.
- 3. Before I got the aluminum, I used cardboard and tape to create the speaker cabinet.
- 4. Test for the shape and stand of the speaker.





Wall mounted modularity

The second concept was about modules as well, but only with maximum four speaker tiles. The concept was based on different wall attachment systems and the possibility to scale the speaker size. The idea was based on the grid which would have helped me to control the dimensions of the manufactured speakers, and therefore define the manufacturing constraints.

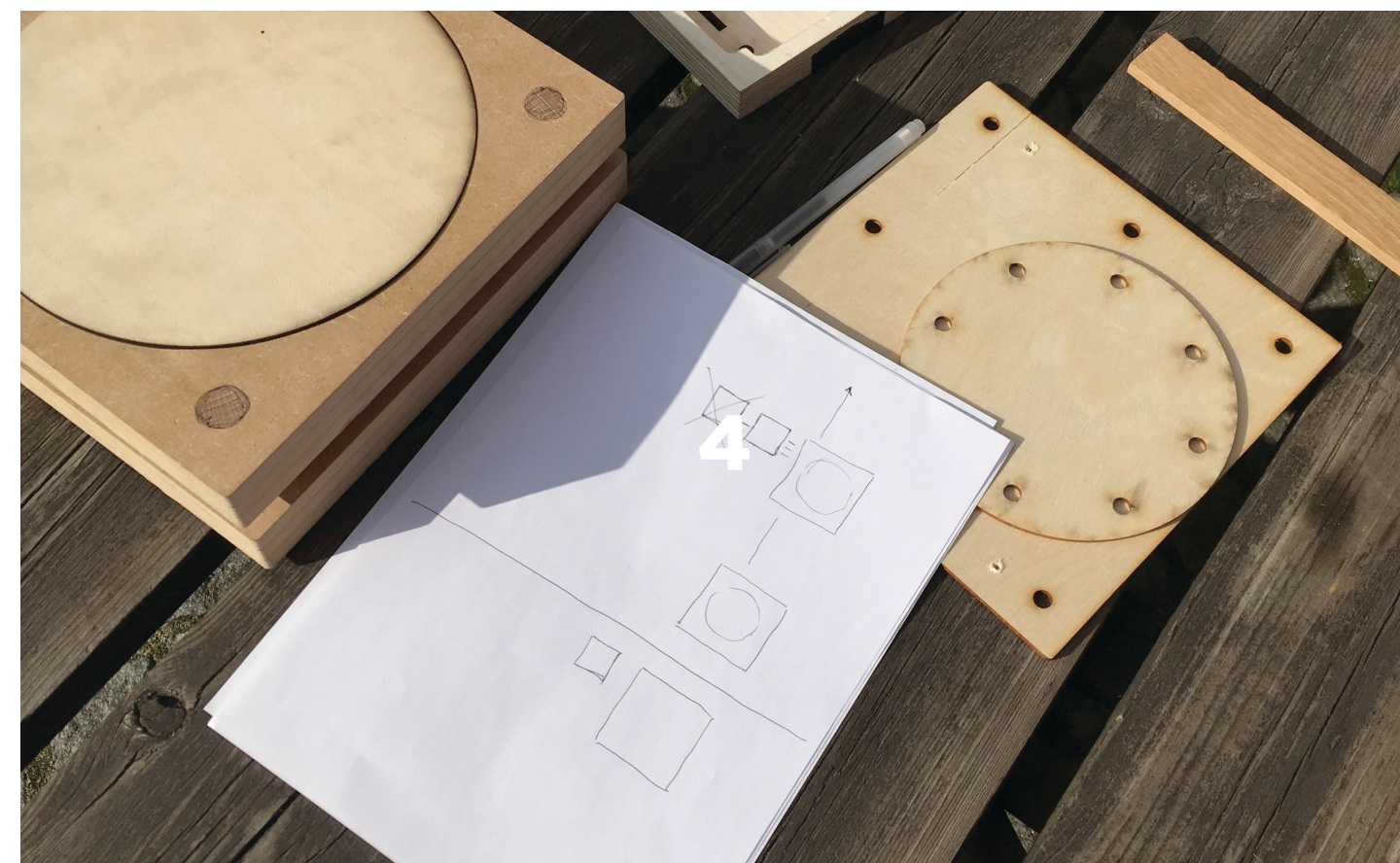
At this point, I started focusing on the manufacturing efficiency. Based on my tests I realized that all the CNC operations had to be well thought as every new or more complicated step increased the time and vulnerability of the process.

1. Grid based sizing system. It was a study to define the different possible sizes for the speaker.

2. Possible use cases for speaker if it was attached with plugs on the wall. The speaker could have taken from the wall and placed on the table in different positions.

3. Idea of the speaker which would be attached to a pole in the wall. That would have allowed the user to tilt the speaker and point the sound wherever it was needed.

4. Sketching and prototyping of how the system would work and what is the attachments method.



Attachments

I made several prototypes from wall built-in and attached speakers. I used standard metal bars and pipe fasteners to prototype the possibilities. The concept would have been rather strong in modularity wise and, from its use case. But, after trying to figure out the different solutions I realized that the process started to cause complexity and difficulties in the stability of the speaker. But, I also started to feel hesitance because the concept did not really provide anything new, just a new way to attach the speaker on the wall. So, I did move on.

- 1. The wall where we could test different placing options. It has holes in it so that we could attach spekers on it.*
- 2. An idea where speaker was built into the wall, but also the CREATE 4-CA is mounted inside the wall.*
- 3. Vertical and horisontal attachment. Vertical allowed to tilt the speaker and direct the sound. The horizontal allowed to move the speaker horisontally.*
- 4. Test of a wall built in speaker.*

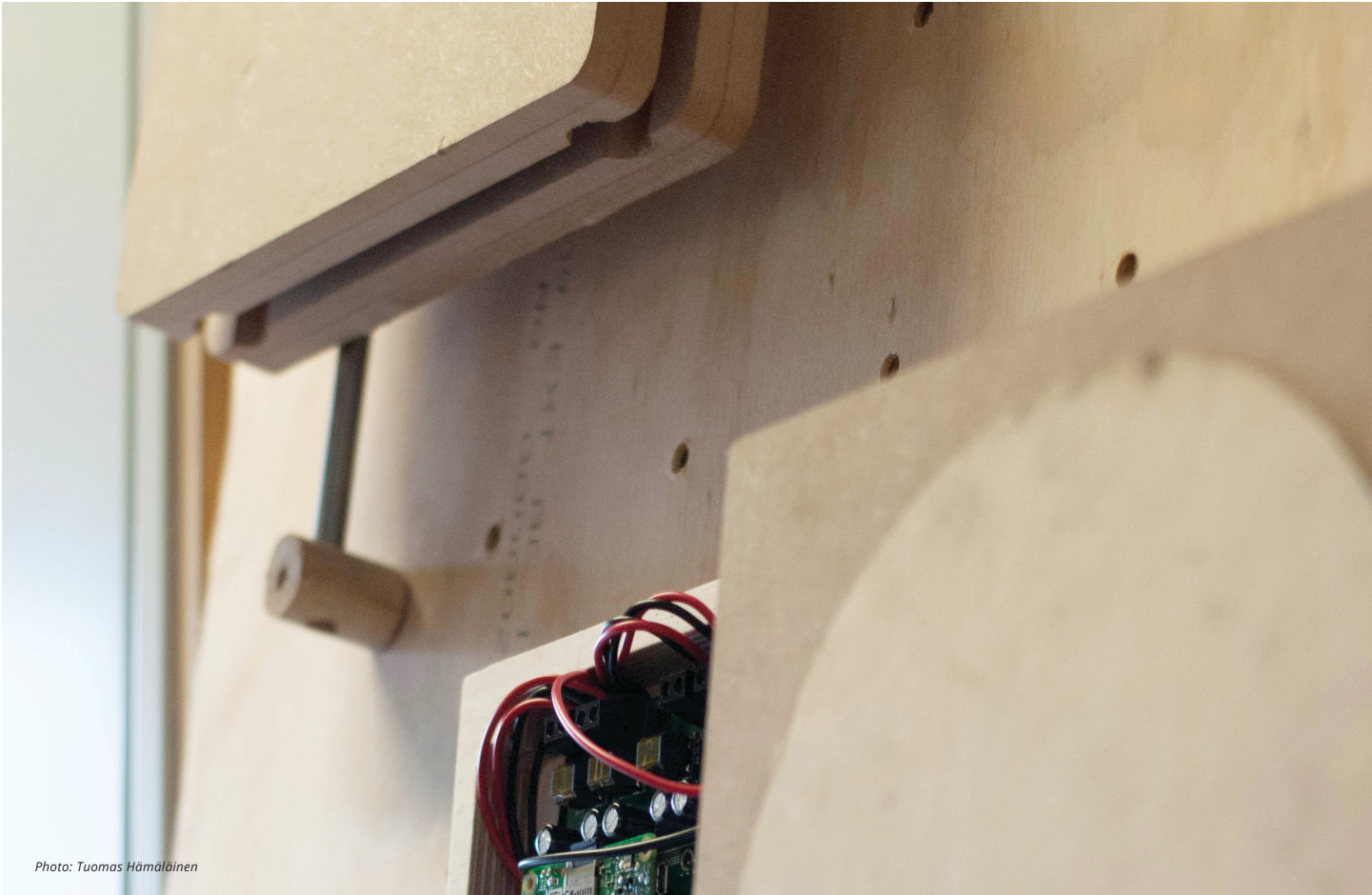
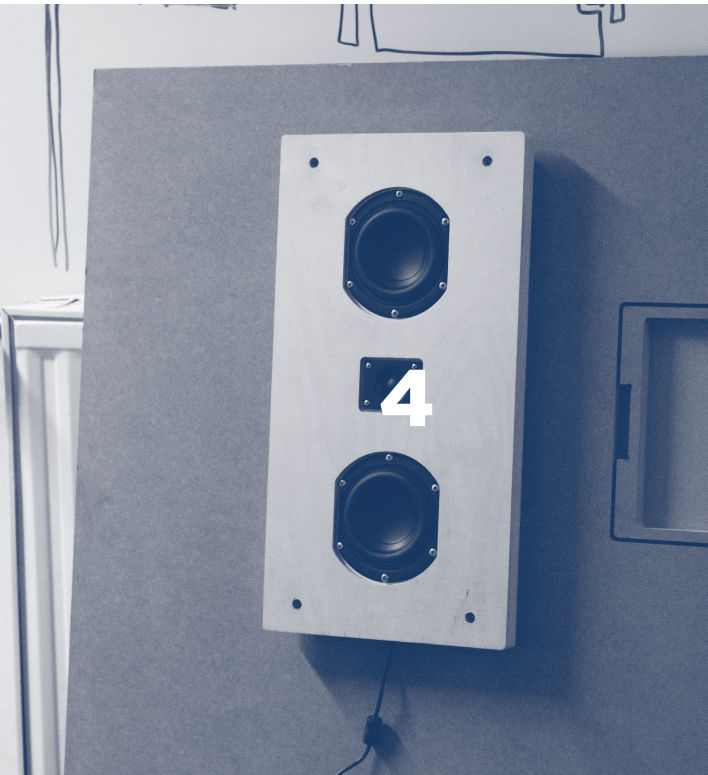
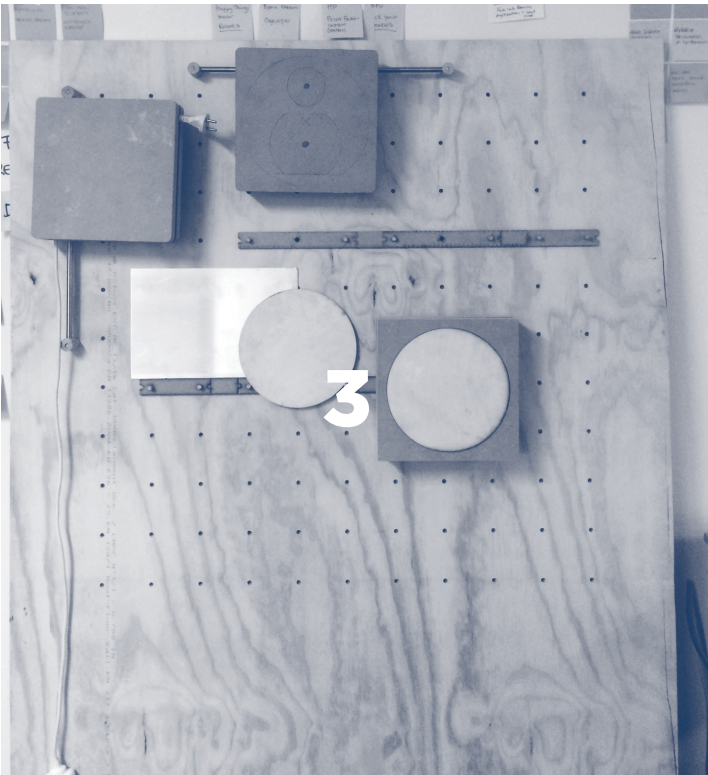
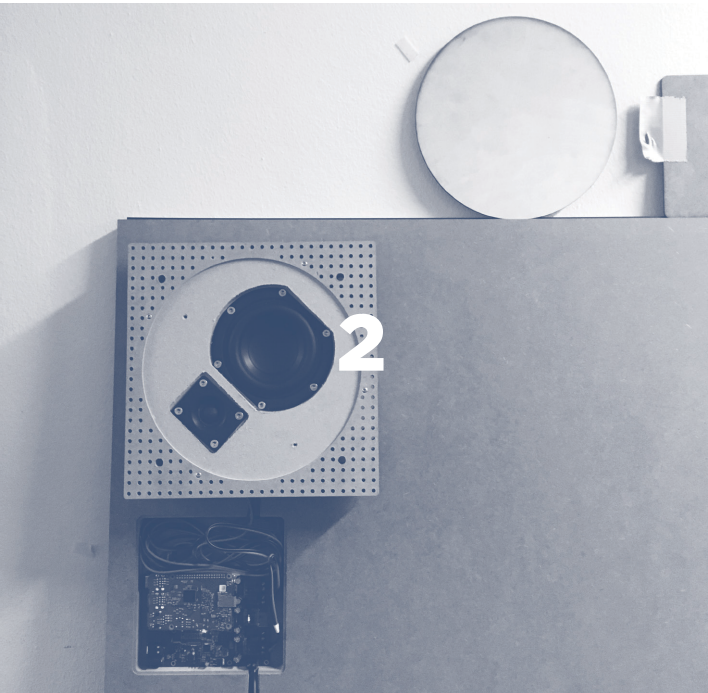
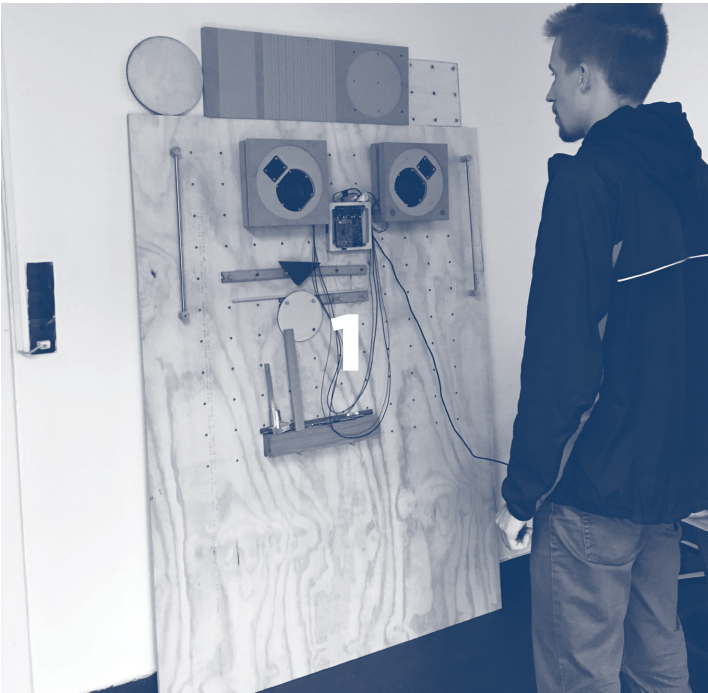


Photo: Tuomas Hämäläinen



“We’re not really interested in the hype. We’re interested in making a difference for people. There is a genuine desire to do something that makes a difference for young adults creating their first home consisting of beautiful, functional design and making it affordable.” -Henrik Most from Ikea

I found the right path

At this point I was aware of the direction that I was taking, using the flat sheets, a simple form and CNC router. But, it was still very unclear to me why am I doing an open design loudspeaker.

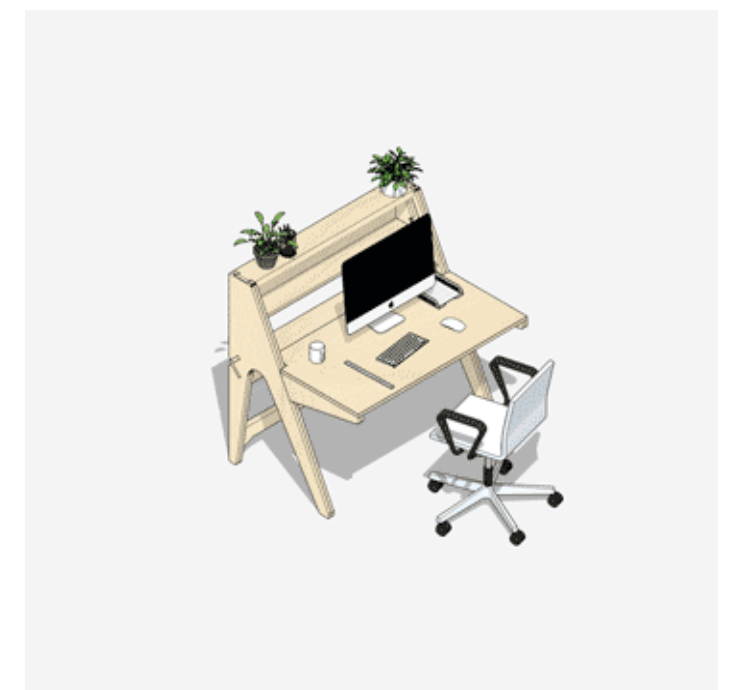
There was the reasoning of providing a platform for makers to play with, but as I see it, the upcoming product should have strong reason to exist and propose something new. The field of open design and local manufacturing are relatively new, so I felt there has to be a lot unreleased potential. It would have felt very underachieving to make another speaker with another look. Of course, manufacturing locally and open design are already sustainable acts, but they are not justifications for products existing. If the product doesn’t provide anything new, we should not even manufacture it just for the look. That led me to keep browsing the internet regularly and, looking what the cultural changes and trends happening right now are.

I bumped into two different projects by Ikea and Open desk. They were about the attitude change towards furnishing interiors and possibilities that digital tools offer us to customize our interiors. These projects revealed me the ongoing trends and direction where we are heading.

After reading about these two projects I realized that we have all the right tools and momentum to propose something related to customizability, and contribute to the manufacturing and distribution systems.



» Ikea and designer Virgil Abloh have started an interesting collaboration called: Tailor-made for millennials. The website doesn’t talk about what the project is actually about, but the article is about that millennials do want to think home and concepts of furniture differently.
<http://ikea.today/tailor-made-millennials-ikea-virgil-abloh/>



» Open desk has project where they provide customizable furnitures. The dimensions can be adjusted and digitally scaled so that it perfectly fits into a specific space.

“Another Dimension: Introducing Tailoring

We want you to be able to tailor the Opendesk design of your choice to perfectly suit your space.”

<https://www.opendesk.cc/blog/another-dimension-introducing-tailoring>

What is customization?

As I noted earlier that adaptability is one of the strategies that open design and local manufacturing can offer, I started thinking what adaptability mean in speaker context? Here adaptability equals to customization. People tend to ask possibility for customized products. That is a way of showing personality, add something special to an interior, etc. But for what we have used to, is the possibility to choose materials, colors and different modules. Is that something a bit naive? It does not contribute to the use of the product; it is only something that might go with ongoing trends. So could we contribute to the functionality of the product and customize it in that way?

Putting together locality, the digital and open design we can manufacture and distribute adaptive loudspeaker designs around the globe. They would be manufactured only on-demand and locally to meet the specific needs.

I realized that we are able to customize the sound. The BeoSound Shape is designed so that it can contribute customization of functionality, but with digital tools and open-design, we can do it as well in local context, and therefore do it more sustainably. Based on the customer survey, people wanted to have sound and speakers which adapts to space. With the mentioned tools we can provide scalable speakers. In this case, it would contribute to matter that bigger space needs a bigger speaker and vice versa. But also, for the matter that we could change the dimensions and therefore adapt the speaker to space.

Designing a scalable speaker could cause a challenge with choosing drivers for changing cabinet size. But, with the DSP and APP that Tuomas is developing we could always tune the speaker, to some extent, no matter what size the cabinet is, or what drivers we are using.

Utilizing CREATE 4-CA

"The Beocreate 4 channel amplifier is a very flexible DSP/DAC/amplifier combination board designed for high-quality music playback in combination with passive loudspeakers." www.hifiberry.com

The most powerful and advantageous functions of the board are the easy connection with DSP, Raspberry Pi, and its wireless capabilities. It is something which frees our hands from the size of the cabinet to some extent. Knowing that it is possible to control the DSP wirelessly from laptop or smartphone is a very intriguing idea. It means flexibility in cabinet design, as we don't have to worry about the size or shape of the cabinet. In other words, DSP makes it possible for us to do customizable and adaptive speaker and always maintain the quality of the sound.

The tonmeister of Bang & Olufsen, Geoff Martin sums the DSP quite clearly.

*"-Visual designers want loudspeakers that are too small
-Amplifiers are usually under-powered
-Power supplies are usually inadequate
-Our customer's rooms have bad acoustics
-Our job is to cover up the mess
-So, we use Digital Signal Processing (DSP)"*



» "The cube" at B & O. It is a unechoing chamber, where acousticians measure the sound from the speakers. Based on the results, Geoff Martin tunes every speaker to its full potential using the DSP.

Photo: Tuomas Hämmäläinen

Embedded in furniture or architectural elements?

My research and experimentation had introduced me to the world of new waves of architecture and furniture. Both practices are struggling with the same problem of sustainability and manufacturing chains, and we have already seen some new solutions from those practices.

My working and ideation process quite often follows a narrative which I create for good design story. The idea where I stuck from the user research was that people didn't want to show their speakers at home or have very minimal speakers. Mainly because they require a lot of space or they didn't fit into the interior. Speakers are also seen as an indicator of taste, which nowadays suggests often modesty and simplicity in an interior. So how could we incorporate the speakers into the homes without causing a disturbance?

I started looking into the homes and first noticed that shelves are also a canvas like walls are. So could we build speakers into the shelves, as it was done in the old speakers in 50s? Or what other structures there might be at home where speaker system could fit? Combining speakers with other locally manufactured structures would contribute perfectly to locality, open design and be possibly creating new distribution systems. These architectural and interior structures were often provided locally made, but they would also provide a platform where open design can be practiced in the future. It felt that there is a lot potential synergy between sound and locally manufactured architectural and interior solutions. It started to feel also a good design story, going back to the era where sound and speakers were part of the interior and not standalone objects.

I had been struggling with the whole concept of open design loudspeakers, but when I started considering architecture and furniture as a pos-

sible platform for a speaker system, it all started making sense. Our living environment consists of architectural elements and furniture and if they would be built locally with CNC-routers, what if we would use the same tool in building the speaker? In that case, the speaker and the platform would be manufactured on the "same table." During this phase, I got introduced to projects like scalable furniture and open, customizable architecture by Open Desk and Wiki houses. Using other products as a platform, would mean that if someone is manufacturing furniture or house, he/she could add the speaker there with almost same effort and tools. It brings meaningfulness to the concept.

The idea of scalable speaker offered something new, and I realized that if it would be combined with something existing, would make it very strong concept. So, the speaker design did not change dramatically, but I found the reasoning for making the speaker.



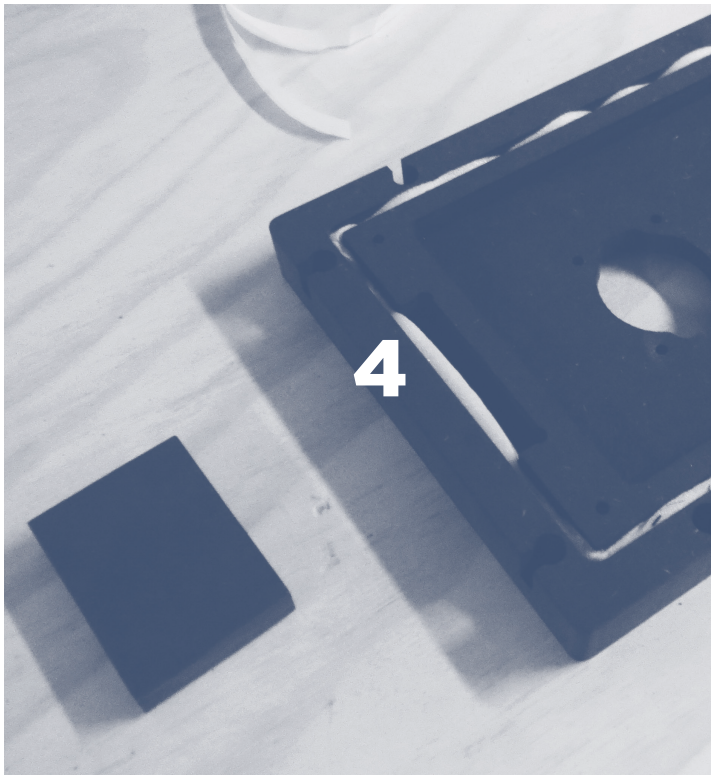
» Building blocks project by Mia Behrens and Johanne Holm-Jensen. In the project they develop modular house construction system. The modules are manufactured only using CNC-router.

Embedded to open-design furniture

I contacted Open Desk for getting their blueprints so that I could build some prototypes. When I had introduced my project to them, they were very excited about it. After building a prototype, I realized that it would need a specific use case and scenario to justify of using furniture as a platform and using only open design furniture as a platform would restrict the use of speakers quite a lot.

I was looking into solutions how to attach the speakers to the furniture but did not find a neat solution for that. Another possibility was to build the speaker into the surface of the furniture, but the materials used in furniture are so thin that it would not have made sense to mount it there. That began to feel too complicated again, and therefore I moved on.

- 1. CNC cut pieces of Open Desk Linnea bookshelf.
- 2. Placing some prototypes in the shelf to figure how they would be attached there.
- 3. Cutting the aluminum which was placed in the ridge of top and bottom plate.
- 4. Details of the top part of the speaker. Holes for the screw attachment, which was used to attach speaker to the shelf. The ridge where the aluminum was placed. The end part which was connecting the aluminum ends.
- 5. The speaker attached to the shelf.



Thoughts about forms & complexity

The work was a lot of trial and errors, and trying to find answers why even do open design loudspeaker systems, and what kind of system? It was a lot about trying to find the right context and justification of doing an open design loudspeaker.

Many of the prototypes done during the early phase were done using flat sheet cut into shape. The cabinet of the speaker was formed using aluminum in between the flat sheets. Aluminum was chosen on the first hand because of its acoustic qualities and distinctive B & O character. First, I tried doing rectangular forms, which turned out to be hard. Then I tried to do circular forms, which was a lot easier. But then the question was that if the basic shape of the speaker was rectangular, why do circular cabinet. The ratio between the cabinet size and speaker size was very ineffective. I tried different possibilities and techniques there to find how to bend the aluminum pieces, but eventually, I realized that it would be too complicated to use aluminum. Achieving consistent results was hard. That would have become a problem when the product is designed following open design principles.

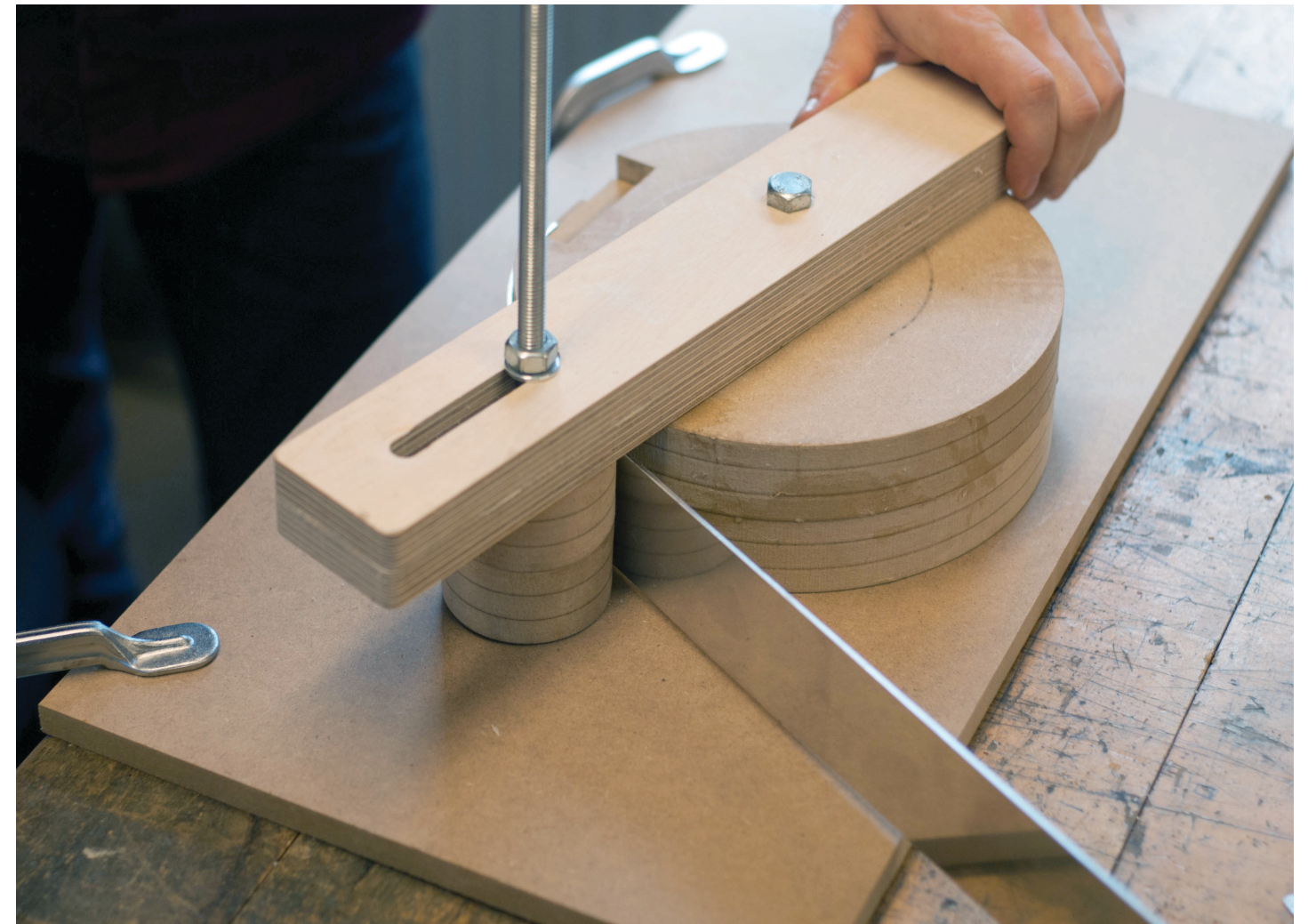
The prototyping was the essential part of the whole project as the context of the project lies in local workshops and manufacturers. It showed me what is it like to manufacture products locally. The entire process I tried to stay as sensitive as possible to feel what methods and actions can be tolerated from the manufacturer point of view. In the end, it became clear that the process of manufacturing product should be straightforward. As when the process became complex, it immediately started accumulating problems. The good example from this is my attempt to use aluminum. Even I tried to reduce the steps in the process to simplify it, the aluminum as a material is tricky to work within maker spaces, like Underbroen.

The problems started from cutting the aluminum; the result was not good which caused tolerance problems when assembling the product. The behavior of the aluminum, when it was bent, was a problem as controlling the mold was challenging without any powerful machines.

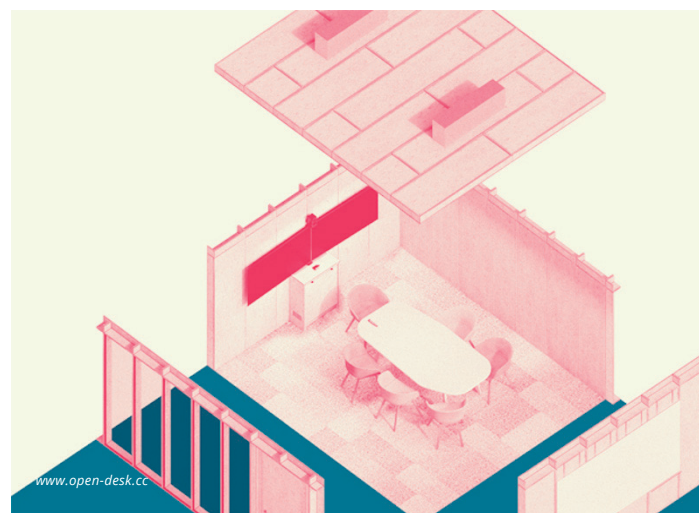
Using the CNC-router defined quite a lot the form factor. First I considered some designs with three-dimensional forms, but quite fast realized that it would quickly double the manufacturing time and effort. Therefore the designs are mainly using two-dimensional shapes.

I had a possibility to talk with architect-in-residence from future agency Space 10. Emil Froege did a project where he studied how CNC could contribute to traditional craftsmanship. The talk with him was very inspiring and revealed an interesting point. He suggested me that I should focus more on the meaning of what using CNC could provide, more than trying to design manufacturable speaker. That probably would have led me to a very complex and, perhaps exciting product, but on the other hand, it wouldn't have contributed to sustainability. Contributing to sustainability globally would require larger scale solutions which can be multiplied. That is how I see it. Therefore I had to decide to design for manufacturing and, not to a one-off showpiece.

» Tool for bending the aluminum between the two plates.



Photos: Tuomas Hamäläinen



» Example of open architectural elements. Googles and Open desks (left up & right) collaboration resulted a modular structures made from flat sheets. The structures can be moved freely to create different size shape spaces.

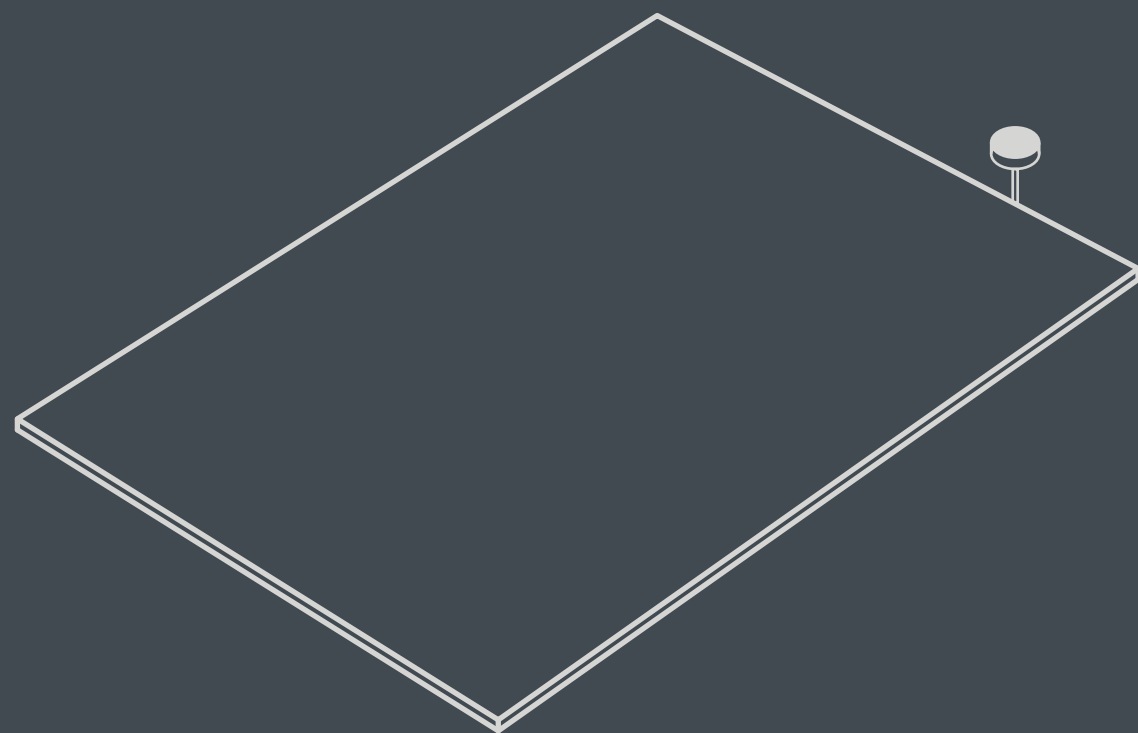
» Space 10 Architects-in-residence Mia Behrens and Johanne Holm-Jensen (left down) have designed a fully customizable and locally manufacturable house. The house can be manufactured only using CNC-router.



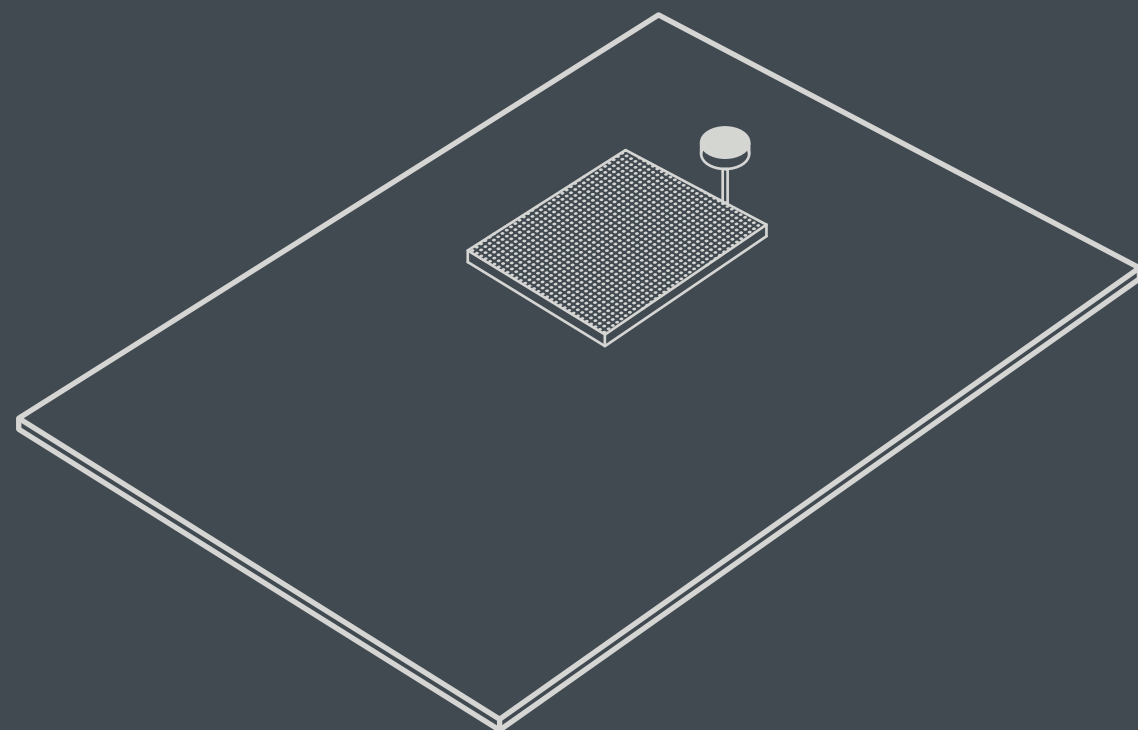
Embedded to architectural elements

After I tried to incorporate the speaker into furniture, I started looking more into the architectural elements which would provide more flexibility and possibilities in the future. With architectural elements I mean modules, and other constructions which are made from flat sheets. Those are used in interiors, constructing houses, etc. The range where the applications could be found is a lot bigger than in furniture. As we have seen, modification and flexibility in homes is increasing, and open-design provides the new possibilities to that. Besides, we can see the coming of architecture which utilizes modular elements manufactured locally. Good examples of these are Open Desks collaboration with Google, or Danish architect Mia Behrens and Johanne Holm-Jensens who are exploring the possibilities of CNC manufactured architectural modules.

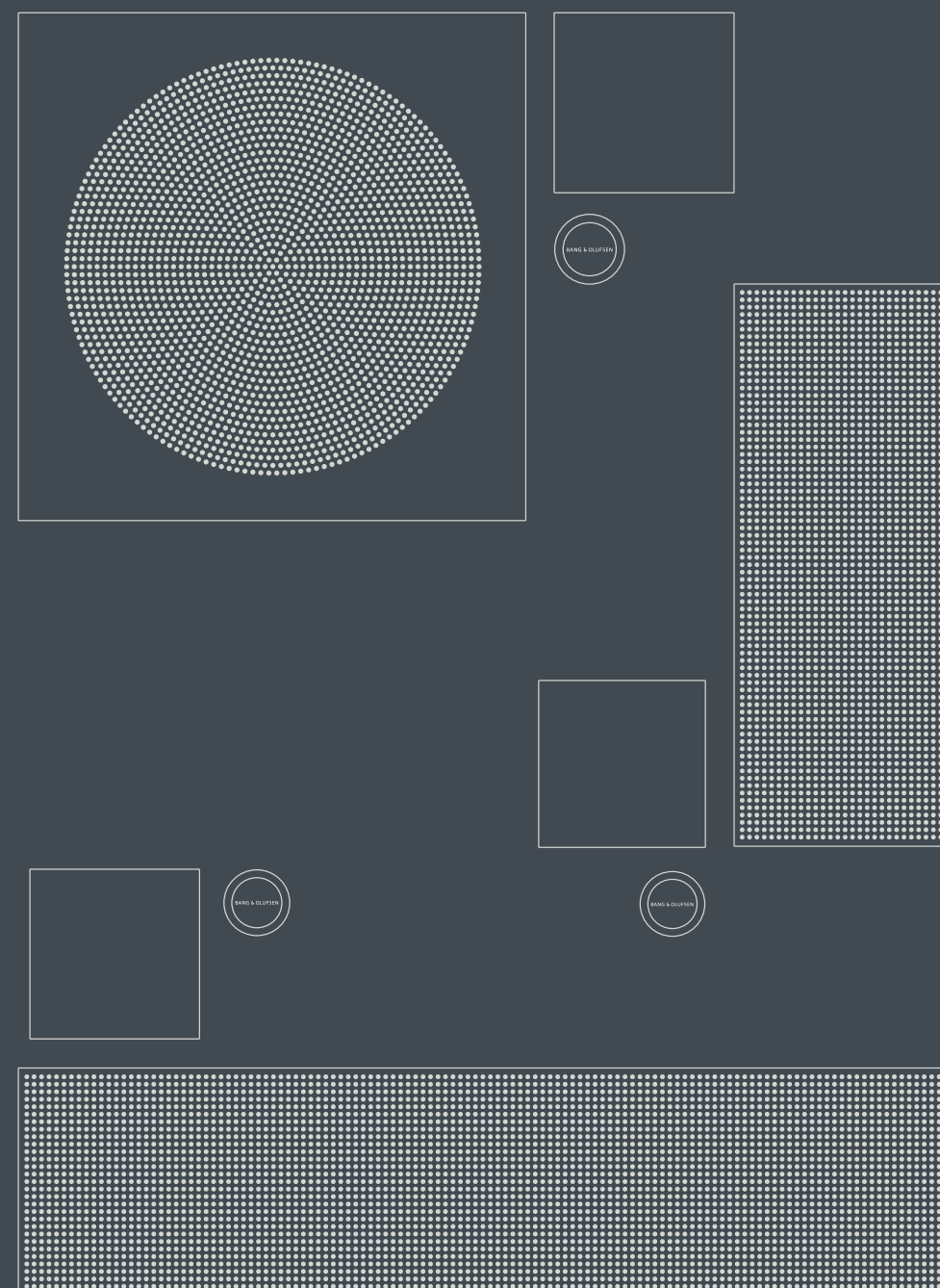
Combining speakers with architectural elements would make it possible to mount the speaker to the wall. That would also improve the story of speaker becoming a natural part of the interior and not a standalone object. That is what people in user survey asked. Mounting the speaker on the wall allows us to hide some of the volumes inside the wall and therefore reduce the bulkiness of the speaker.



» The modules for architecture are often cut to shape with CNC-router.



» The specific size speaker and its parts can be cutted at the same time with the modules.



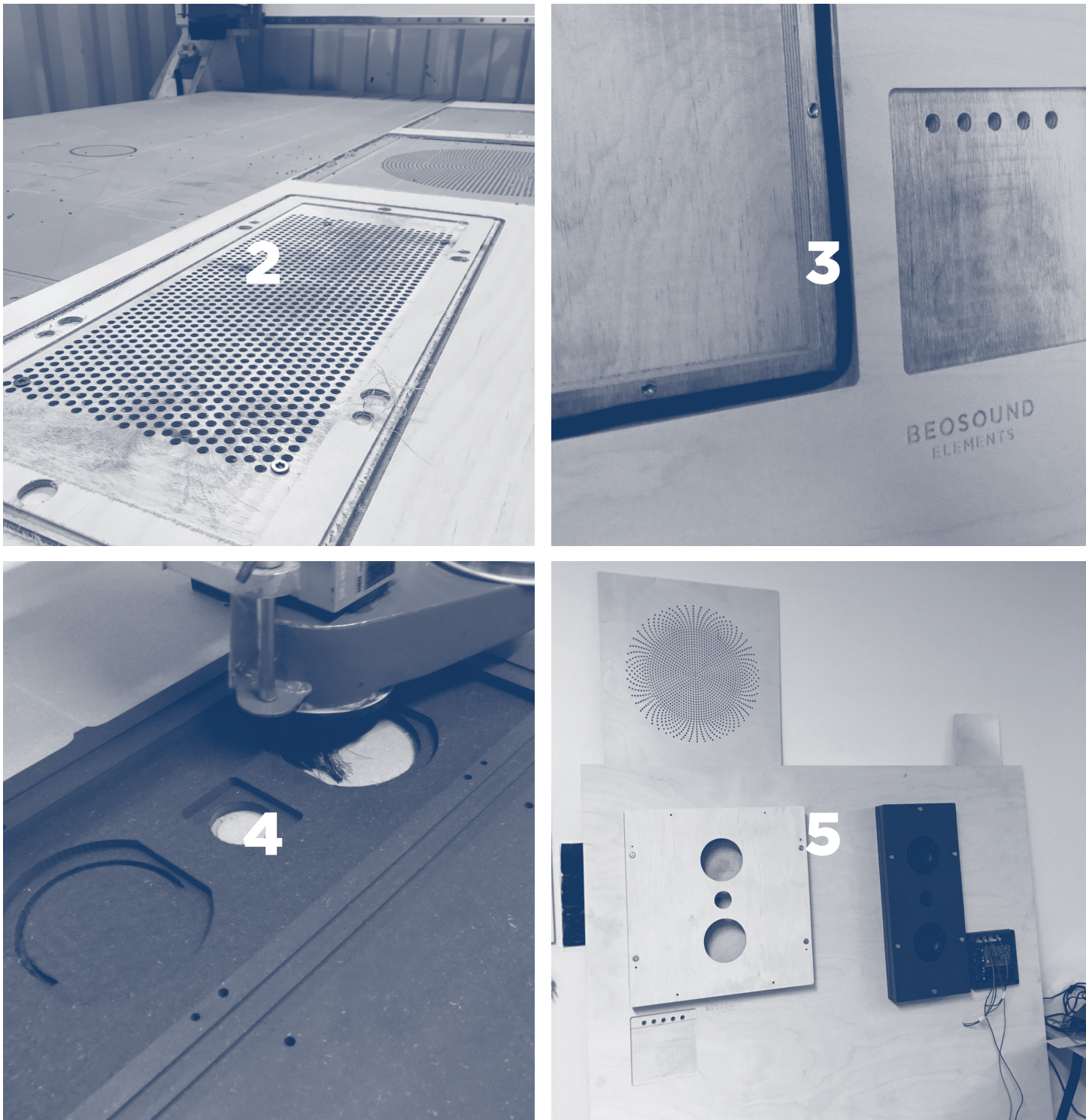
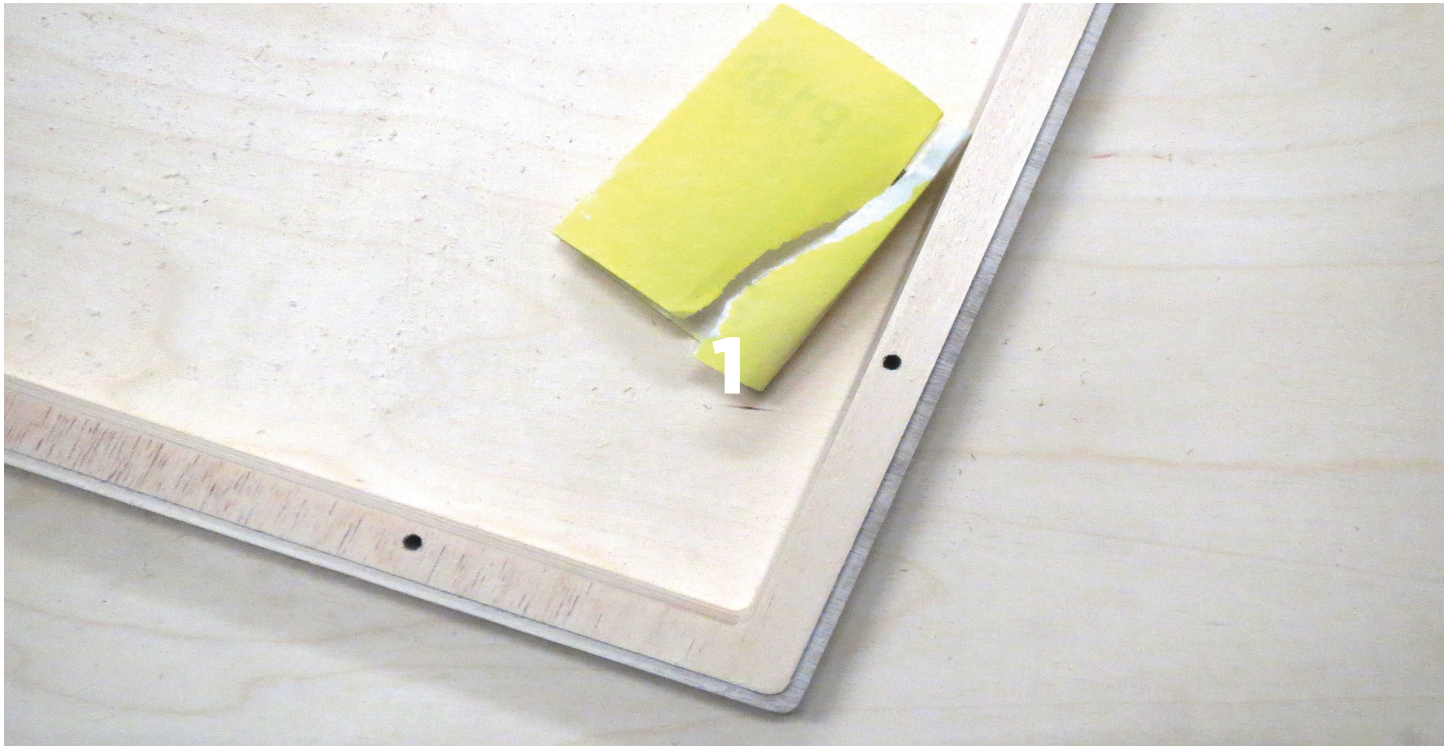
» The speaker dimensions can be decided based on the look, the amount of sound needed or, the by area where it will be placed. Additional wall mounted controllers from B & O existing product portfolio could be placed next to the speaker.

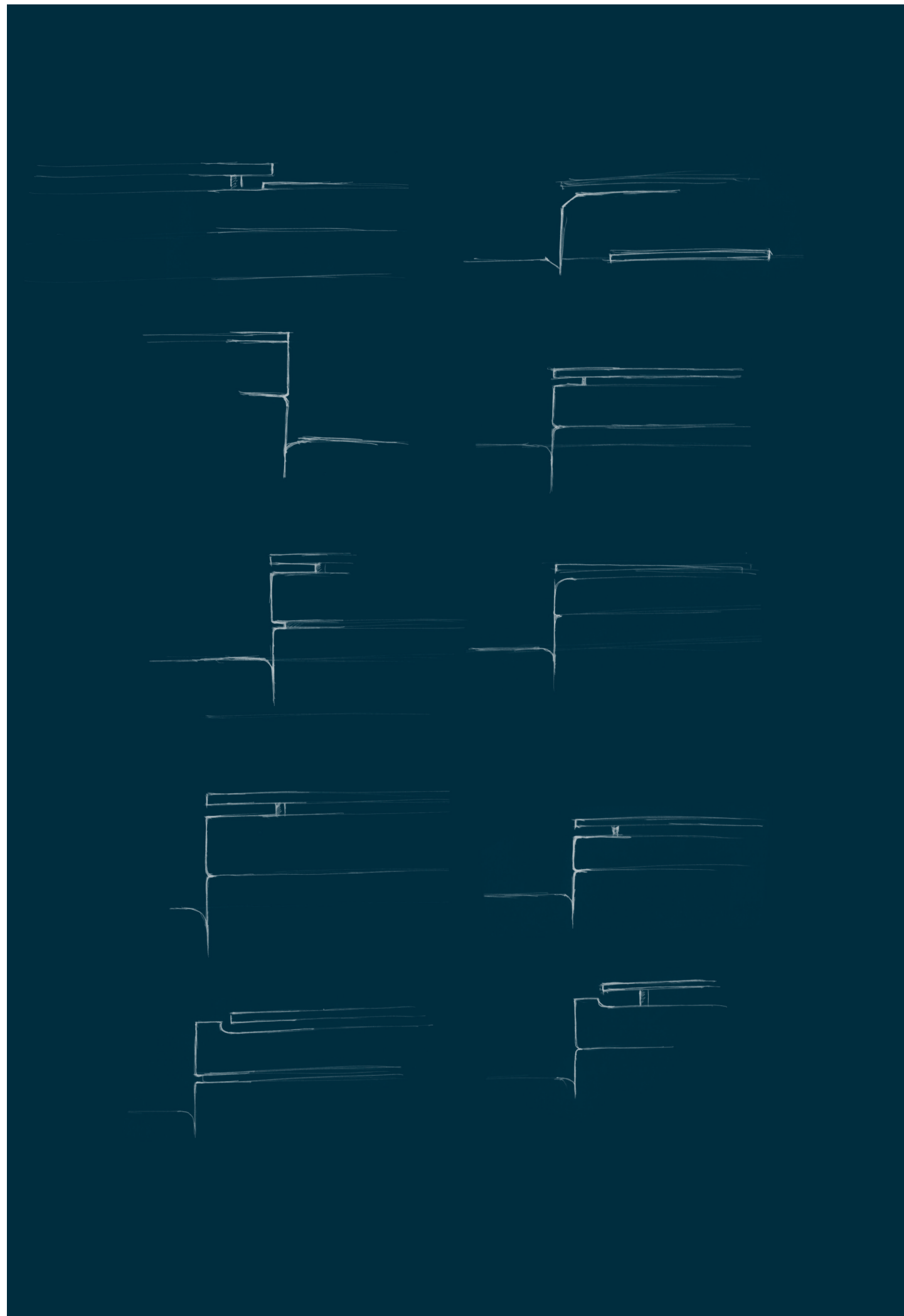
Mounting speaker to sheet material

In the last prototype, I made I got rid of the aluminum and used instead of a "frame" which made the construction simpler and easily scalable. Now the speaker construction consisted from the "target-wall" where the speaker was mounted, a frame, a deck and a grill. The grill is attached to the deck to cover the drivers. The new construction allows the scalability and changing every dimension in the design.

When milling the frame, there is always a piece that comes out of it. It could be considered as a leftover, and therefore I thought the braces and ribs could be done out of it. After some thinking, I realized that actually, that would cause smaller pieces of leftovers. One larger leftover, is better than several small leftovers?

- 1. The frame which will be mounted to the wall.
- 2. Milling the grill for rectangular shape speaker. The pockets are for magnets and housing the assembly screws.
- 3. A pocket for the speaker and CREATE Core milled to the sheet. The holes are for wiring which goes in the back of the sheet.
- 4. I asked acoustician if the driver attachment could be done from the backside. That enabled me to do the milling only from one side which eased the manufacturing process dramatically.
- 5. The final prototypes made in Denmark. I made one rectangular and one square shape. The rectangular one was fully working prototype and tuned for the best sound.





Detailing

I milled many of the prototypes from the both sides of the sheet. I learned how to do it quite accurately, but it started feeling very complex and vulnerable process when I was looking for simplicity and replicability. Therefore I ended up mounting the drivers from the backside as it provided me the opportunity to mill the sheet only from one side. I asked from Jakob Dyreby (acoustician) if it was possible, and he said yes.

I sketched a lot of detailing to create some character for the design. The sketches are from the side of the speaker. As I ended milling the top plate from the back, I could not do detailing from the front side. That was the decision which led to a very simple design.



Design for scaling

If I think about what sort of forms I can stretch and scale without losing any forms or changing the nature of the product, I don't have too many options. The result is either square/rectangle or circle. I was first going into the circle shape but then realized that circle always grows in two directions, which is very restrictive and does not allow us to do sound bars. So what was left, was a rectangular form? That is also one of the main reasons for the speaker's visual design.

But even if the customization and scaling become possible due to local manufacturing and digital tools, it still needs adaptation from the digital design process. The CNC-cuts the pieces based on the paths from a 3D model, therefore the model should be customizable easily as well.

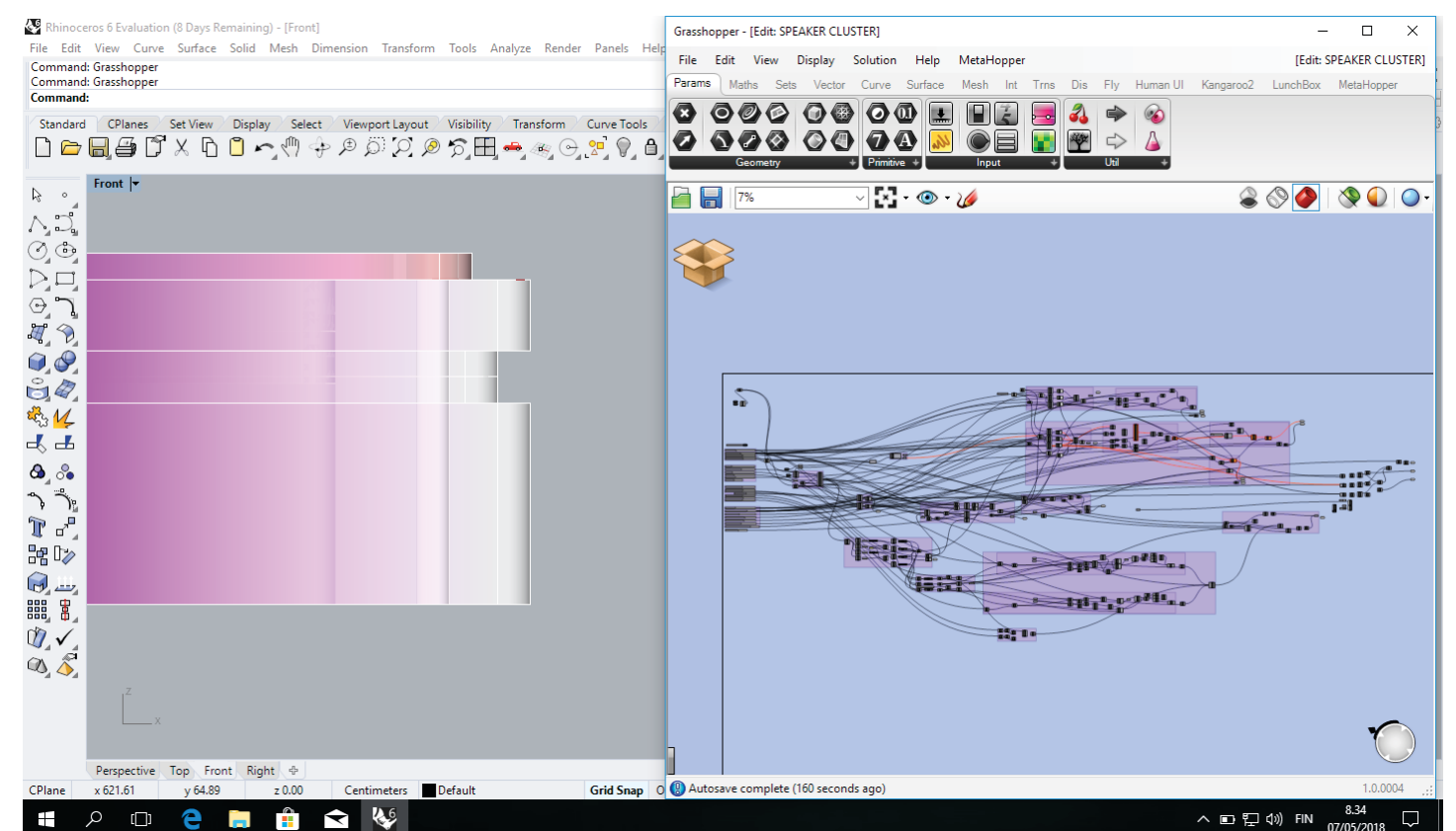
The problem I had with conventional 3D modeling was that, if I wanted to change the dimensions of the speaker, or thickness of materials, I had to 3D model the whole speaker, and every part again. That was very time consuming and inefficient. Therefore I needed to go into parametric modeling. Parametric modeling means that I can change one parameter in the object and all the other will change according to that one parameter. Being able to modify the product parametrically, the entire manufacturing process got a lot faster and frictionless.

I did not have extensive knowledge of parametric modeling plugin for Rhinoceros called Grasshopper, and therefore I contacted a person who helped me. With the help of Aleksi Rastas from Muuan Architects, we made a parametric model with Rhino Grasshopper from the rectangular design. At that point, I realized the design should be based on "rules," because using Grasshopper is about setting rules for actions, like in coding. Getting to know that it probably would have been beneficial to do the whole design process with

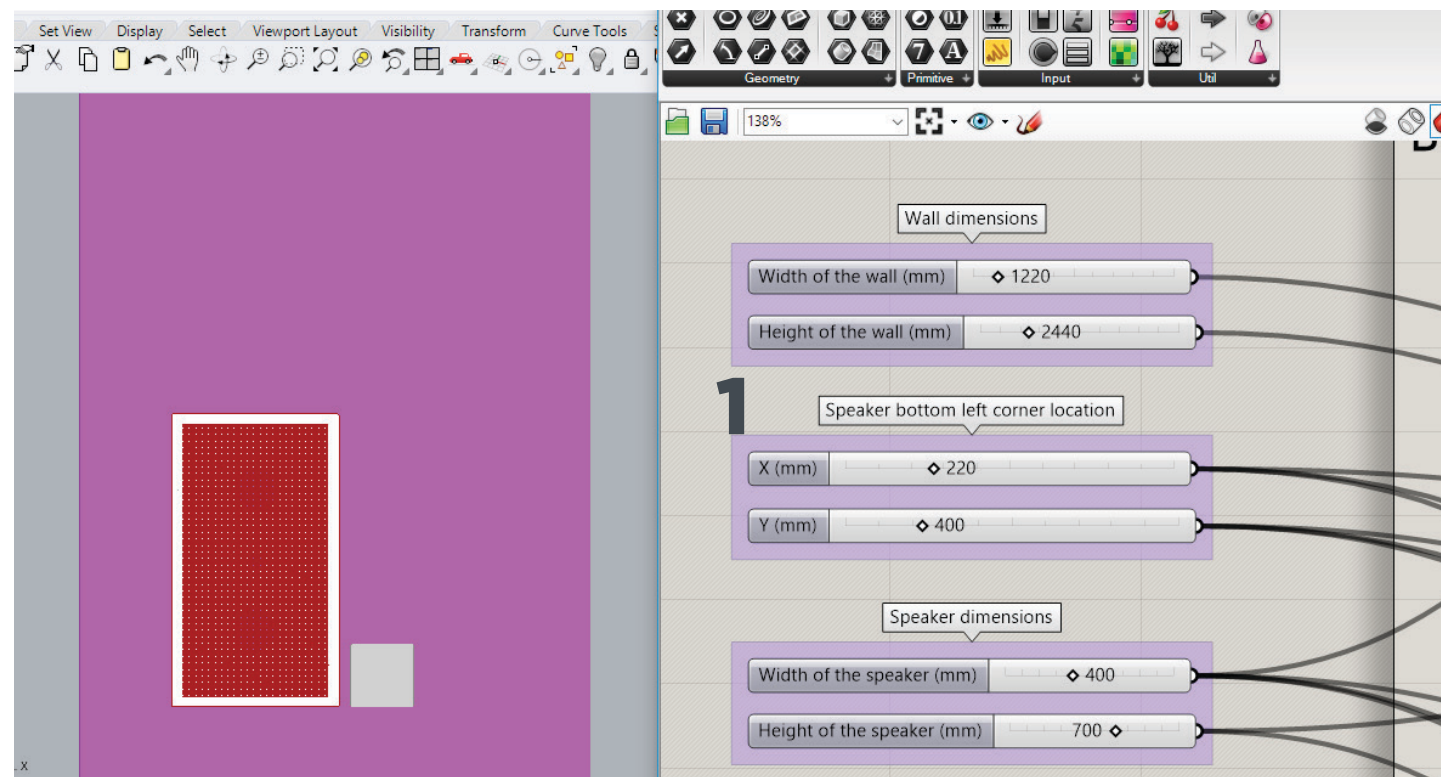
Grasshopper, to be able to use the form finding features of Grasshopper.

I got an entirely new aspect for the design process. It would require another thesis to explain design for Grasshopper, but the main thing was that all the design decisions had to be made thinking of "what happens when I scale the speaker?". For example, how many assembly screws there would be if the size increases by number x , or where are they located? For these questions, I do not have an answer in this thesis. This sort of issues needs to be assessed if the final parametric model is created. But, the model we made confirmed that it is not a problem. The design has to be made using only forms that can be naturally scaled.

With Grasshopper, the design turns into very generative, which is one principle of open design. A person who can use grasshopper could easily modify the design, and the size of the speaker. For example, the different grill patterns can be easily explored and generated with Grasshopper. Still, later on, I intend to develop a web-based interface for designing the system. In that case, one doesn't have to use grasshopper for modifying and manufacturing the speaker.

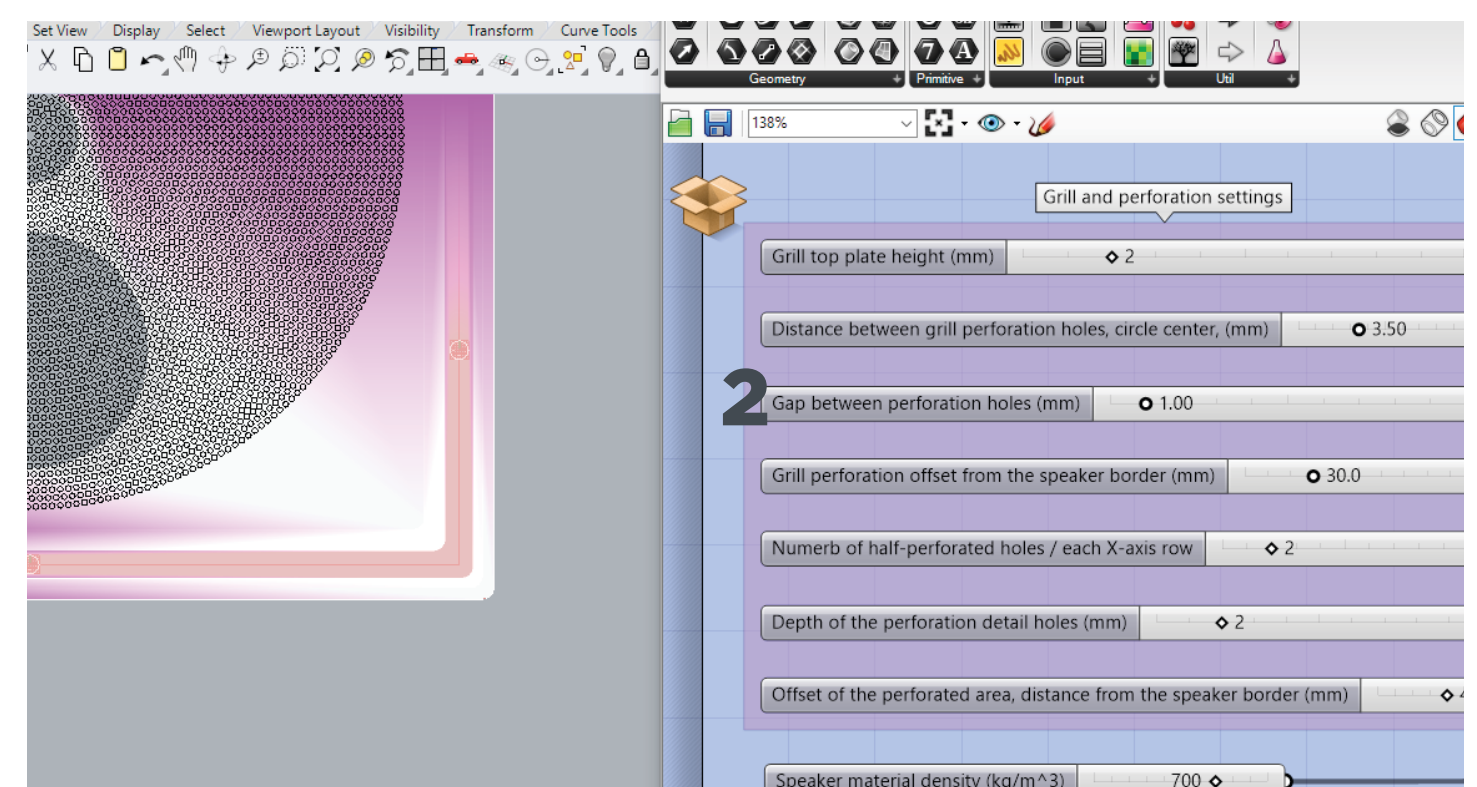
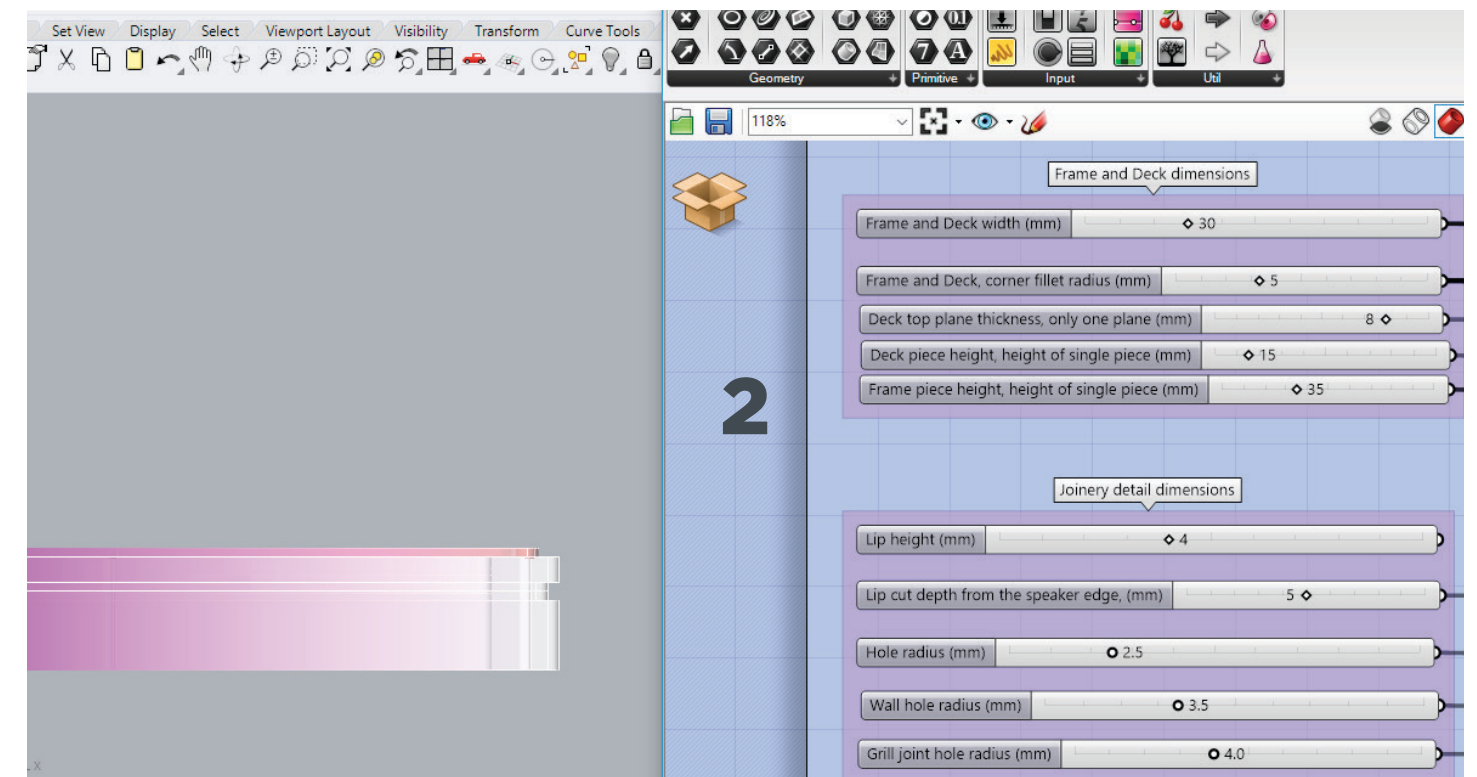


» Grasshopper plugin for Rhinoceros is a graphical algorithm generator. The user sets definitions and actions which are then connected with wires.



1. In the grasshopper setup one can set the size for the speaker, and placement on the sheet. With every change in dimensions, all the other dimensions changes accordingly.

2. In the deeper setups, one can change every detail, dimension or radius in the speaker. That comes handy when the available materials, screws etc. are different in different locations.



Design for manufacturing

As I see the whole concept, it becomes one if the product could be repeatedly manufactured and not needing any unique crafting. That is also one principle of open-design. Therefore I could say that the product is viable, and addresses its purpose if the manufacturing process can be streamlined.

As I have been discussing a lot what the balance between easy manufacturing and complex forms, here I explain more what kind of decisions I had to make to streamline the manufacturing process in local context.

First of all, when using CNC-router, we have to understand what does it require to use it. During the process, I learned how to use it, which informed a lot of the decisions. For example, every tool change takes about 10 minutes and needs to be planned carefully. It sounds little time, but when there is many of them, it starts to take its toll. Therefore I tried to design all the parts so that most of the forms, cutting, etc. could be done with as few tool changes as possible. In practice, it means that the radiuses are same, there would not be holes or cuts where one tool cannot fit. That is also a reason why I decided not to use different size holes on the speaker grill, even visually it might have created exciting effects. Another aspect was the decision whether to mill from two sides or only one side. Milling from two sides allows the maker to do more complex and diverse products, and it is not very difficult. But, as I have noted earlier, when there are more steps the process tends to become more vulnerable. However the complexity of two side milling depends also on what kind of CNC one is using, does it have suction, or some other method for fastening the product to the table.

Using the CNC and trying different things I ended up going into, minimal design and easy manufacturing. That was because I started feeling that the hesitance to manufacture started increasing fast if the product went complex. CNC-routing allows very complex and extraordinary looking results, but doing them would take the product far from replicability. It has to be simple. I also talked with a maker, co-founder, and owner of the Underbroen, Christopher Nielsen and asked how long it should take maximum to build speaker system so that it would still be doable and feasible. His answer was maximum 8 hours. Based on my experimentation, that time limit was quickly passed with a more complex design.

I continually tried to develop the processes so that it would be less time consuming and more efficient.

» Often the material had to be secured to the milling table with screws.

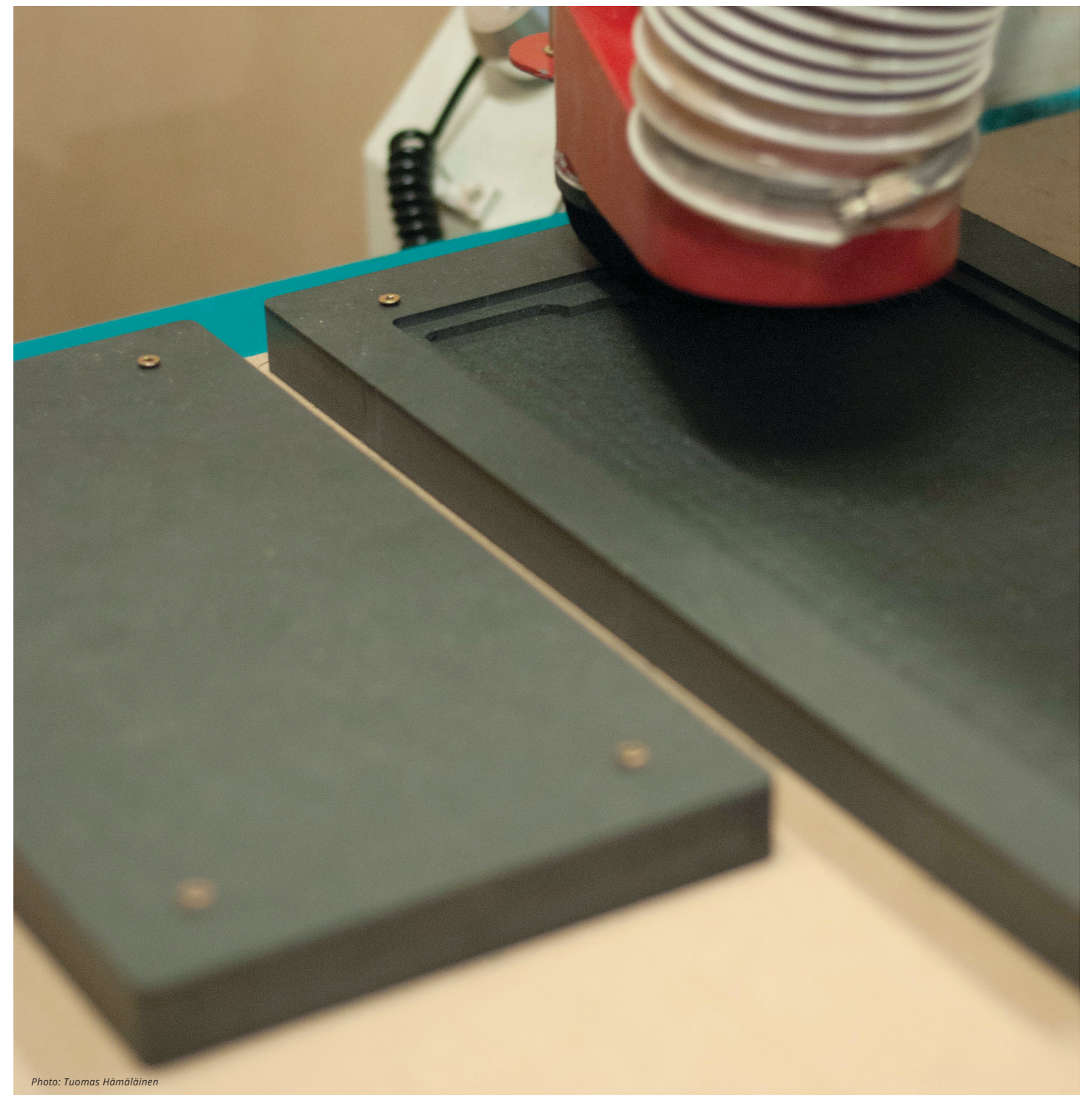
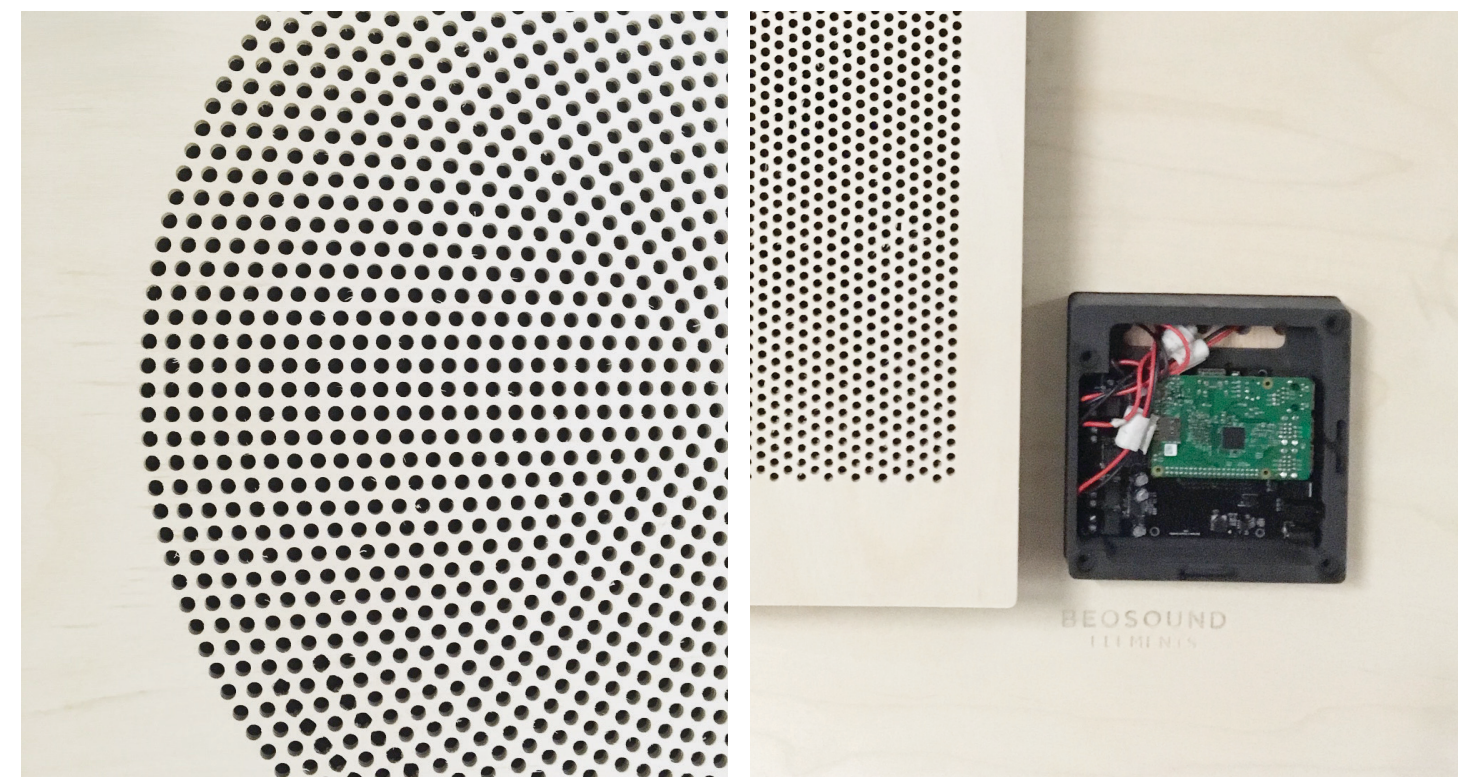


Photo: Tuomas Hämmäläinen



Last prototypes

The last prototypes made in Copenhagen were fully functional, which proved that the concept, hardware, and DSP worked. The prototypes were made out of black MDF, and plywood. The BeoCreate core (the box for CREATE 4-CA, Tuomas' work) was made out of MDF and aluminum. I felt that I had learned quite many crucial things, to be ready to execute a proper product. After making this prototype the concept was ready, and I started planning the final product with final materials.





» All the prototypes made during the prototyping phase.



4.4 The concept of BeoCreate Elements

BeoCreate Elements is a scalable wall built-in speaker, which can be manufactured locally with the same tools than many interior solutions, and architectural elements. Combining the speaker with other structures, it gives it a whole new meaning. It is not a speaker anymore; it is part of our built environment, and not an add-on speaker. The scalability and usage of flat sheet material hold a strong message about its origin, flexible and adaptive product design. BeoCreate Elements fit peoples need for having a personal and curated life.

The BeoCreate Elements is powered by the CREATE 4-CA amplifier with digital signal processing (DSP) and wireless streaming capabilities. The size of the speaker can vary while the speaker can hold up to four drivers. For example, two 4" woofers and two tweeters, depending on the size of the speaker.

The BeoCreate Elements works with the APP from where one can set up the whole system. Based on the dimensions of the speaker, the person can tune the sound using the DSP control in the APP. It means that the same drivers can be used in different size cabinets. The bigger the cabinet, the bigger the sound, and vice versa.

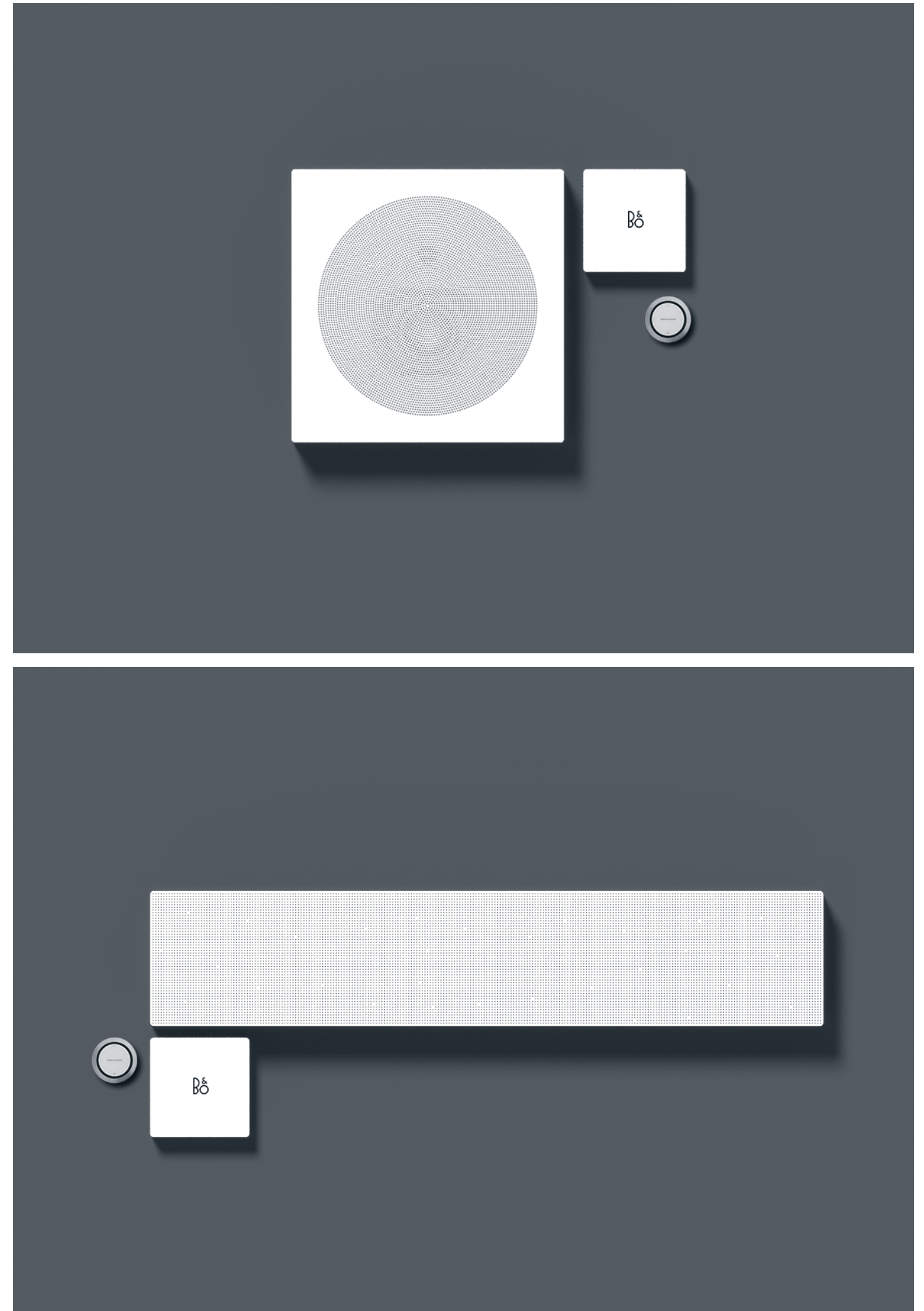
With this combination, the whole system can be customized by/for the customer. Not only the placement and size but also the sound.

The AMP box is located next to the speaker because if software or hardware updates occur, it is reasonable to be able to do the updates without opening the whole speaker. Visually it is telling the story of openness and flexibility.

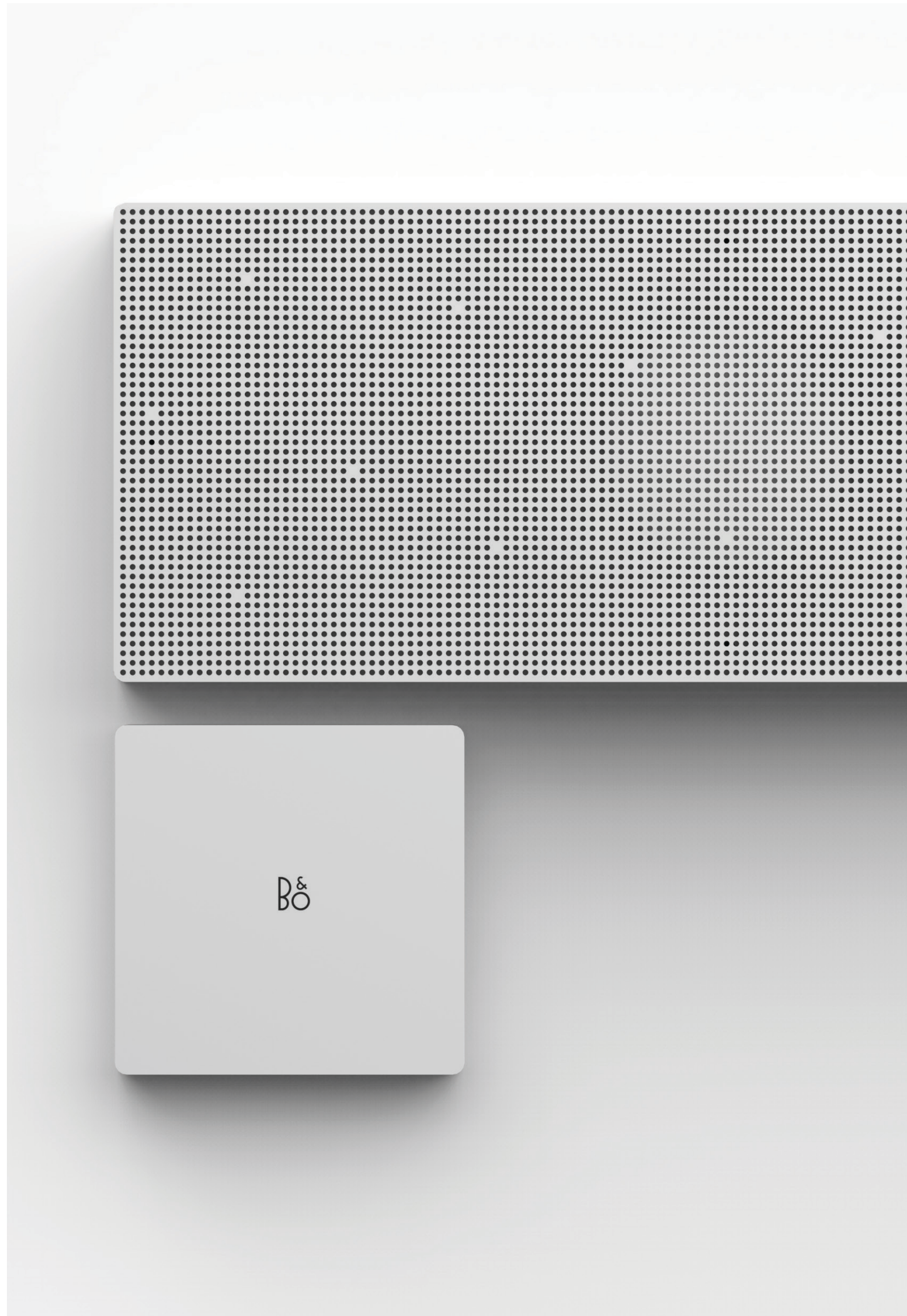
The BeoCreate Elements can be paired with BeoSound Essence which is a wireless controller for on/off/play/pause/next/previous. From the perspective of form factor, these two products fit well together. Besides that, Essence demonstrates that open-design products can be paired with the current B & O product line.

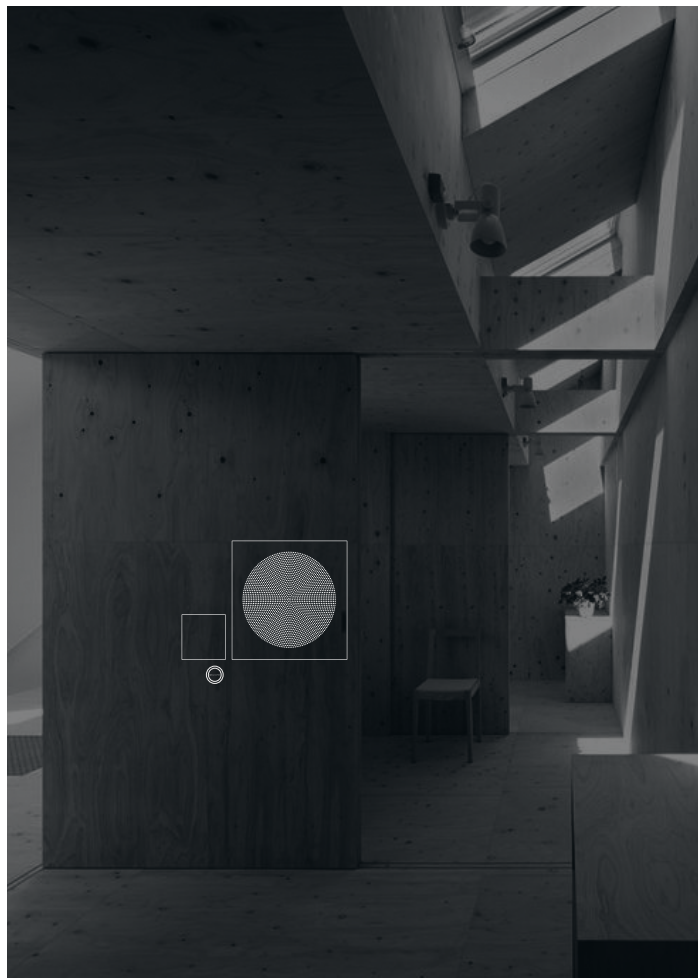
The design is a result of three factors. The first one is an adaptivity, which means that form of the speaker needs to be able to scale without losing any form. The second factor is easy and frictionless manufacturing. The layered design makes the construction and assembly understandable and straightforward. The third factor is the possibility to use different materials for customization. That is enabled by the use of only sheet material of different thicknesses.

The result is a speaker which serves as a platform for adaptivity, customization, and is generative. The flexibility has been achieved by designing each part as simple as possible, which turns into really minimalistic form factor for the whole system.









» The possibility to scale the speaker allows a person precisely decide where the speaker is located. It can be fitted even places where nothing else can not be placed. With the DSP, the speaker can be always tuned for the environment.



Changes and additions

During spring 2018, Tuomas and I had a chance to visit Struer and the headquarter of B & O again. The purpose of the visit was to improve, and look more about the acoustics of our product. During the internship, I focused more on creating a meaningful concept, and not too much for the acoustics. Besides that, we were able to get some other comments as well.

The main intake from Struer was that we should reinforce the structure to prevent the cabinet making any unwanted resonance. We should put ribs and braces inside to stiffen the structure. Acoustician Jakob Dyreby said that both ribs, and braces are needed. In practice, it meant that when I am milling the pocket in the wall, I would leave some material there to work as ribs. The ribs could be designed to form squares; then I could cut right size dampening materials and place them into the square slots. From the crossings of the ribs, the 3D printed braces would go to the top deck. From the top deck, screws would go through the braces and attach to the wall stiffening the whole structure.

Moreover, we discussed the grill holing and the drivers. For the grill holing, Jakob Dyreby suggested 25% acoustic transparency for bass and midrange drivers. For the tweeter, he said the transparency should be at least 40%.

The last prototype I made had three drivers. One woofer, one midrange, and one tweeter. During the visit the acousticians suggested me to do 2-way speaker which would be easier to tune with the DSP algorithm than the previous three-way speaker.

In the further discussions with acousticians, we decided to mount the drivers from the top of the deck. That caused a challenge because it meant, we had to do the milling from the top. First, my designer attitude said, no. But, I realized that actually, it would benefit me, because then I could do all the grill mounts, etc. from the top, which allows more functional design, and easier manufacturing. Another aspect was that the top deck becomes thinner, which caused a better looking visual design. Now, the bottom frame was a bit thicker, the deck thinner, and grill attachment easier. That was an excellent example of why designers should listen to people with different expertise.

The grill holders (circles in the picture) had to be changed as well because then we were able to reduce the need of deck's raw material. The new solution would be 3D printed plugs, which will be glued on specific pockets milled to the deck.

Based on the feedback I did some changes to design to deliver the last iteration of the project. The design changes were mainly seen in the deck design and fastening solutions.

» *Me assessing the new deck piece.*

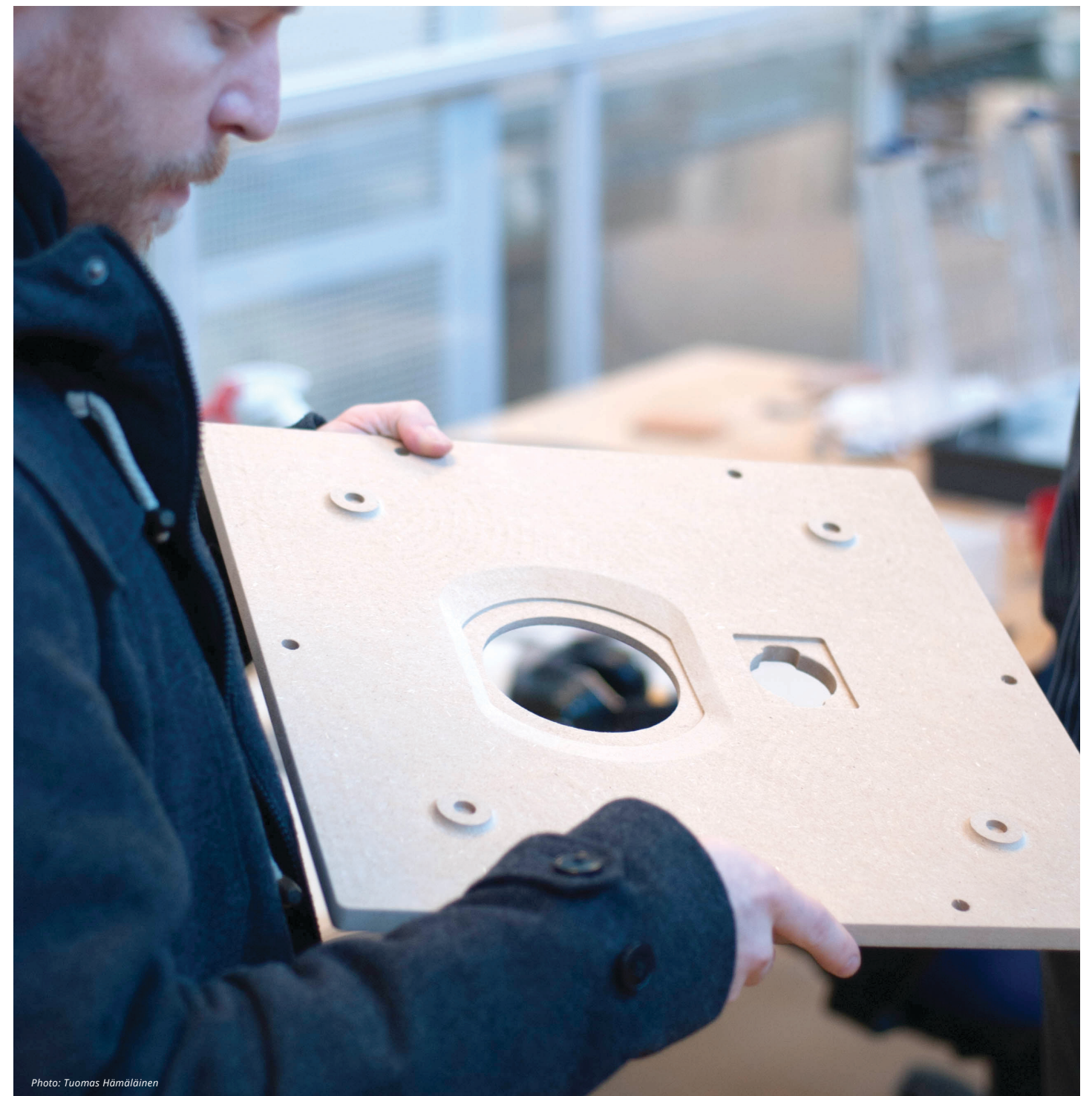


Photo: Tuomas Hämäläinen



Question marks

The exciting news we got, was that the acoustics department had hired an intern to look for the algorithm for the DSP. The intern would later as well propose a driver placement and other suggestions when he advances in his project. That will probably happen after this thesis is already handed.

Another subject he started working on was the number of drivers that one speaker should hold. Theoretically, it can hold four, but it is also dependent on the DSP algorithm, which is under development. The third thing the acoustic intern is looking for is the limit in a cabinet size when additional drivers or bigger drivers should be used. It is about defining the limitations in the cabinet size.

One always have to remember that the size of the cabinet, and driver size/amount should be in balance.

» Discussion with acoustical engineer Jakob Dyreby.

Bang & Olufsen style

Bang & Olufsen has a very distinctive style which separates it from other audio manufacturers. Based on my notions, it might be a consequence of very unusual forms, and combinations of materials. It seems that the company has always first decided how the product is going to look and afterward started thinking acoustics, and how a product is manufactured. Naturally, the manufacturing process affects the price as well.

The B & O style is very graphical and known for its material combinations. Almost in every product, we can see wedges, stripes or other separating elements between materials. They kind of lift the appearance of different materials. Another very distinctive factor is the subtle forms and details, which creates the magical feeling, and attracts people's attention.

The company very often combines materials like oak, aluminum, and black plastic. The combination evokes a very classy feeling as aluminum and black plastic are distant and cold, but combined with warm oak makes it more approachable. The materials and combinations vary between B & O and BEOPLAY, while B & O is more serious, and BEOPLAY is more playful.

The manufacturing methods and designing for scaling affected quite a lot to the overall design. I had constantly debated in my head how much I should respect complex forms, from which Bang & Olufsen is known for. I decided not to respect them at all. For that, there are several reasons. First, I think B & O should go back more straightforward style, but also reduce the manufacturing costs which are high at the moment. Therefore the simple style in my project is more like a statement. The simplicity could make the Bang & Olufsen products more affordable again, but the question is: should they be affordable or maintain the luxury status? In my opinion, come down from the

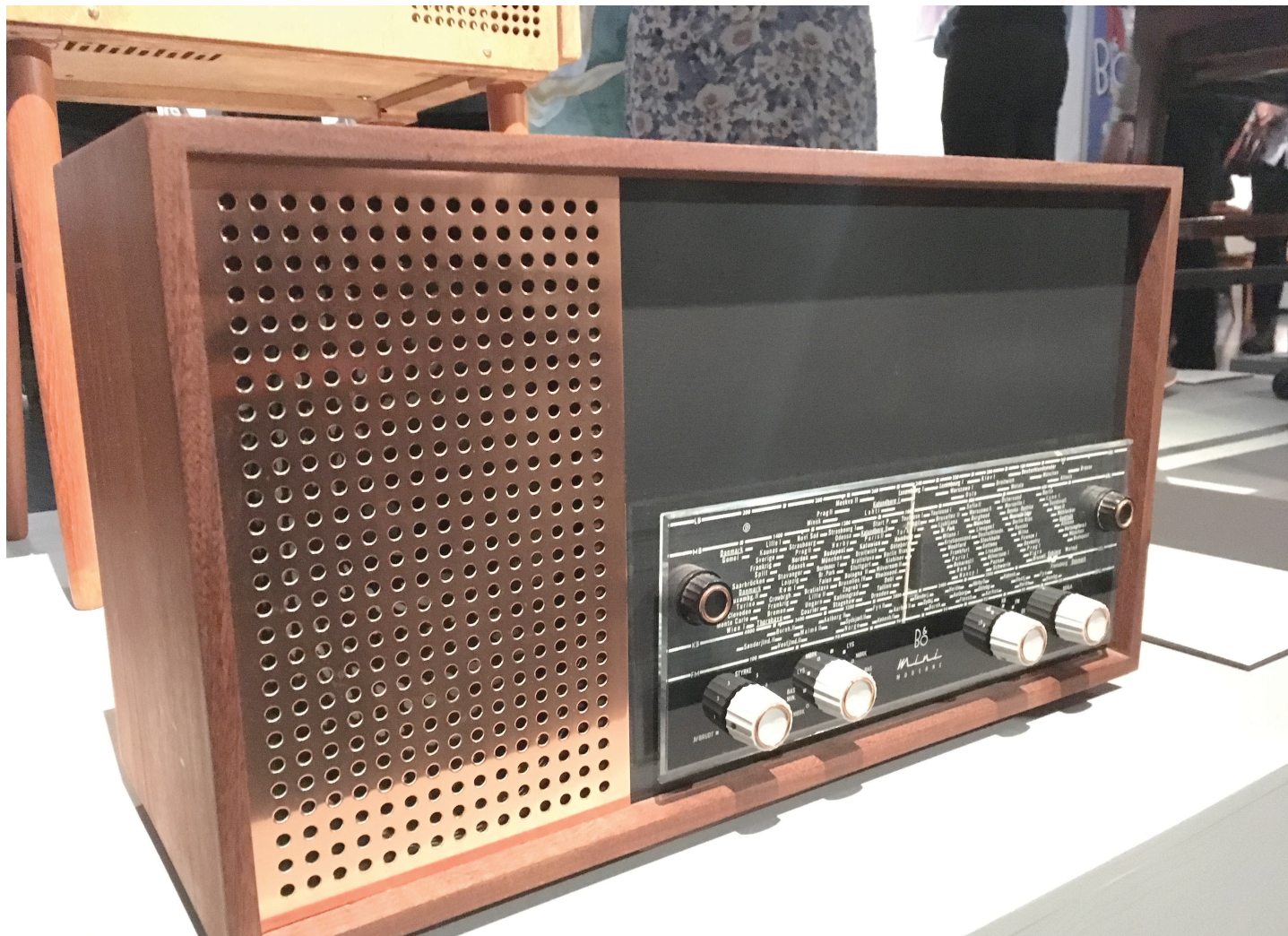
clouds. Another reason was that I am doing the project under CREATE, and therefore I felt that I can suggest something that differs from the current B & O style. Regarding the style, Lyle Clarke, the head of the concept exploration, also stated an interesting point. He asked if there even was a thing called "B & O style," and immediately answered, "no." The style has changed during the times depending on who has been the designer.

Still, for the design, I looked at some elements from the B & O products, like the gap between different materials. Using the wedge is the result of the usage of flat sheet material, and pure visual design. The wedge makes the design look lighter and works as a line between possibly different materials. During the design process, I have tried to keep in mind the maximum potential for different material combinations. Bang & Olufsen often justifies the use of aluminum with an argument, that using aluminum, the product blends naturally into the environment. That is also something that I wanted to address. People wanted simple and almost invisible speakers. Therefore I used the shiny grill which blends the speaker into the environment.

The decision to use a circular grill-holing shape in a square speaker was easy, as it creates a very distinctive visual contrast. The intention in doing so was to evoke a magical feeling but remain very simple and graphical. In my opinion, when a designer is going into a very minimalist style, it has to go through the whole product. Therefore for the rectangular shape, I decided to go and follow the shape with holing. Bang & Olufsen has used widely different sized holing in their products. I considered that as well, but chose not to go there as it immediately adds complexity to the manufacturing process. It was a lot of weighing what matters more, the manufacturing, and replicability or complicated design.



» BeoLab 17, BeoLab 19 and BeoLab 18 are part of B & O Home-product portfolio.



» Mini Moderne 606 K, 1959 by Helge Frank Morthensen is the first product where Bang & Olufsen used a designer in the product development process.

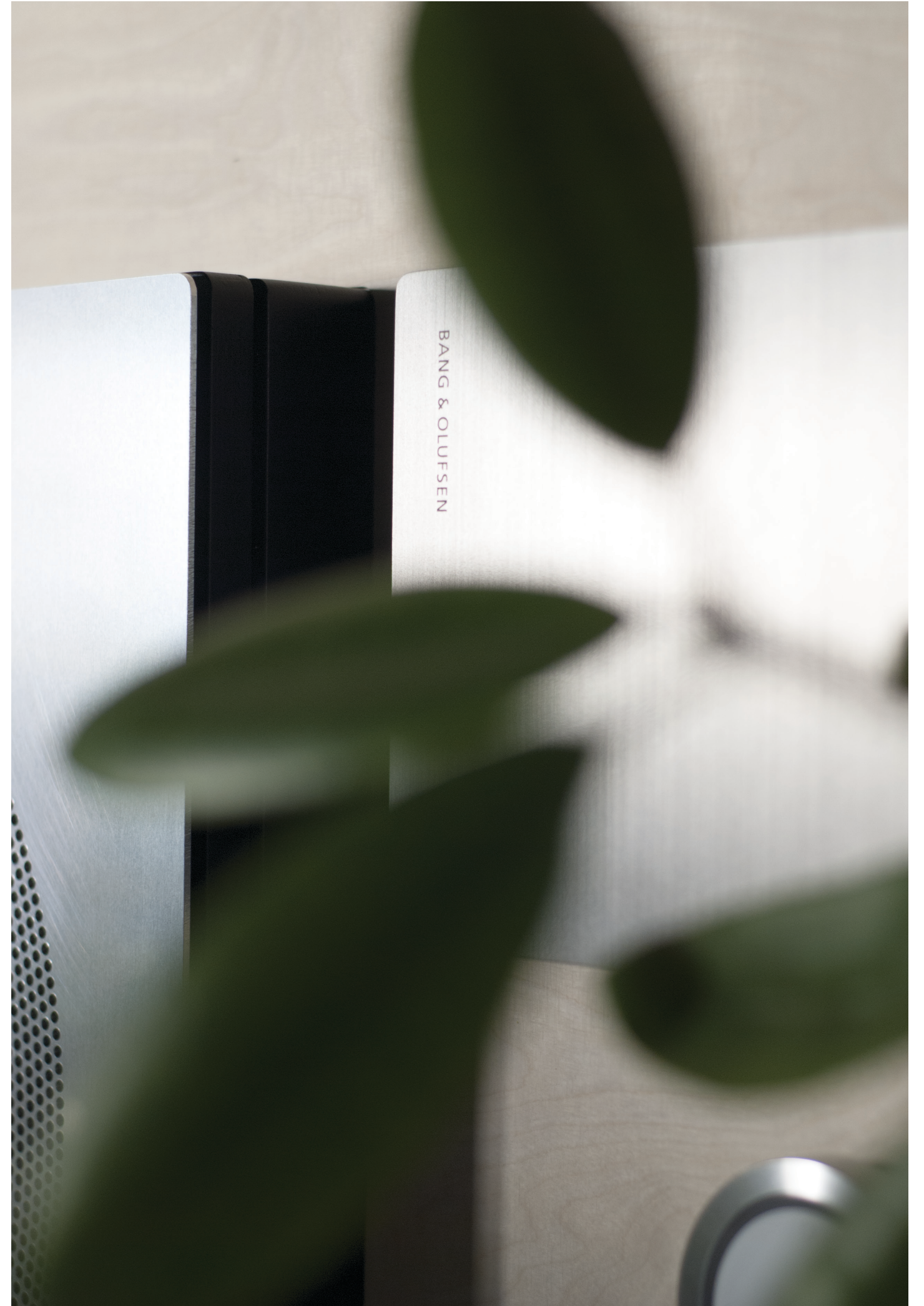
» These two audio systems are good examples of the simplicity, and design of old Bang & Olufsen products. They were manufactured for the masses, and average citizens.

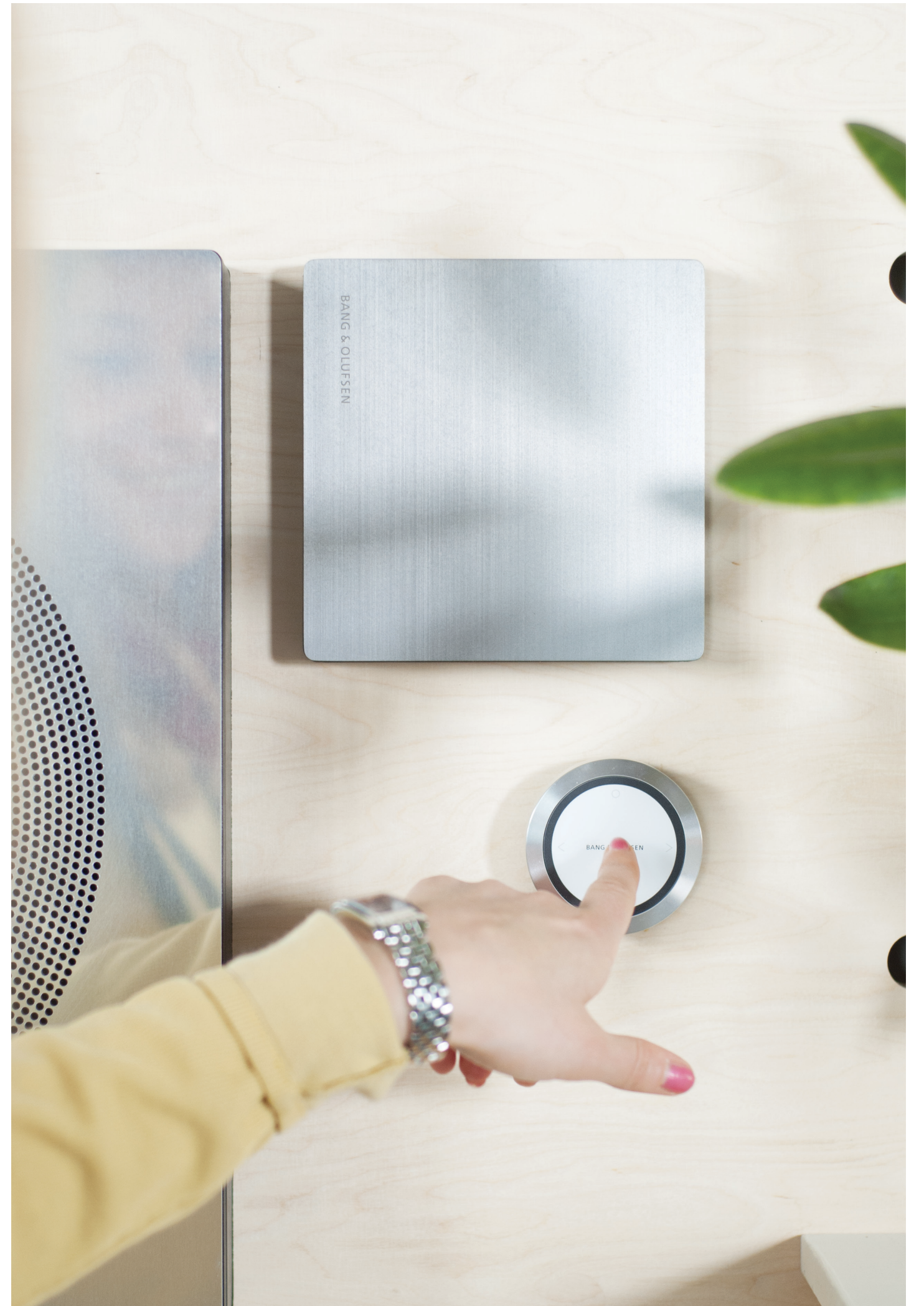


» Audio system from the 60`s embedded to furniture.

4.5 BeoCreate Elements

In this occasion, the BeoCreate Elements is embedded to a shelving system for a private home. Its graphical appearance creates a good match with the shelf, offering a very distinctive entirety. The size is decided based on the size of the room, and how it fit to the shelf.







Manufacturing

This is not a complete guide for manufacturing the speaker, but compiled to show the main points, and considerations of it. In the future, I am planning to compile the full instructions and publish it on the internet.

For manufacturing the speaker, one needs to assess the placement of the speaker, and consider what is the thickness of the "target-wall." The thicker the wall, the thinner the speaker and vice versa. Still, one should leave 5mm thickness between the pocket, and backside of the wall. That is for ensuring the stiffness of the structure. Things to keep in mind when designing the grill: the acoustic transparency, and the ratio between time, amount of holes, and diameter of holes.

About choosing the materials, even though I have used plywood and painted it, I encourage people to try different funky colour, and material combinations. Basically, the grill, deck, frame, and wall can all be made from different materials. One just has to make sure that the used CNC router can tolerate the chosen material. For choosing the materials for the frame and deck, I advise considering how thick the raw material is. Too thick material causes waste.

The tools needed depends on what materials and machines one has. So, that needs to be assessed in each case. But, here I have gathered almost the minimum tools one needs for the manufacturing.

Tools needed:

- CNC -router
- Screw driver
- Sanding paper (depends on the material)
- Paint (depends of preference)
- Strong glue
- 3D -printer (optional)

Materials needed:

- Any flat sheet material
- Screws
- Magnets
- Dampening material
- Drivers
- Sealant

Sourcing:

- The drivers can be ordered from Tymphany, www.tymphany.com.
- The CREATE 4-CA -board can be ordered from www.hifiberry.com
- The sheets should be sourced from local manufacturer

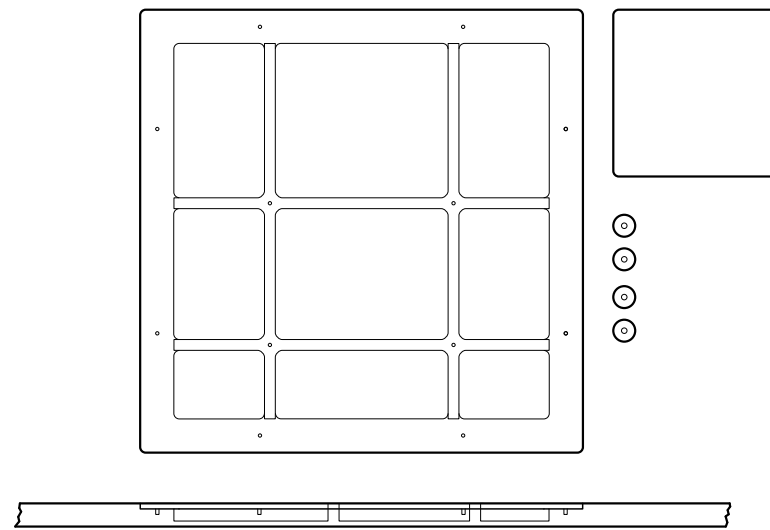
Total milling operations: 9

Mills needed: 1 x 10mm flat end,
1 x 10mm ball end, 1 x 3mm drill bit

Time needed: 5 < 8h

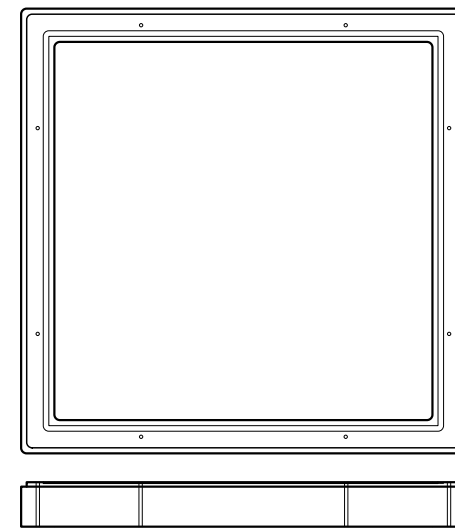


Pocket



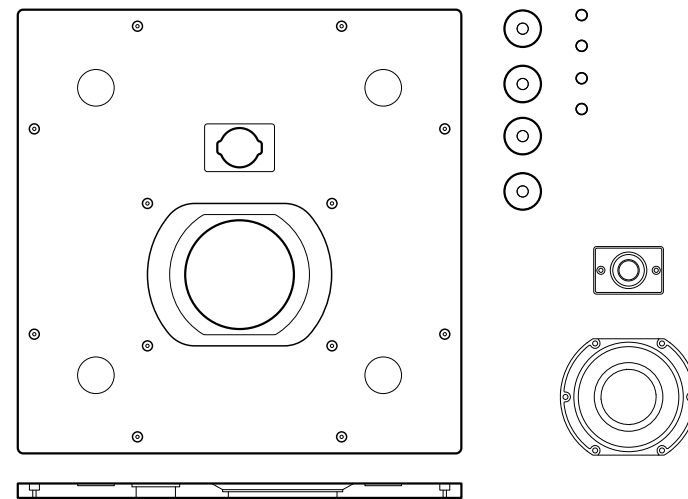
The pocket and ribs are milled with 10mm flat end mill.

Frame



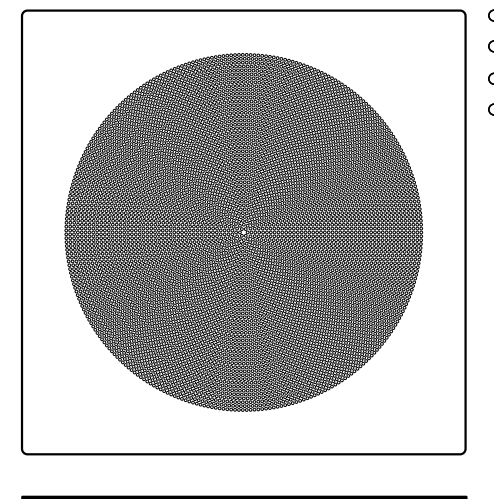
The minimum frame thickness is 39mm. The frame is milled with 10mm flat end mill, and holes with 3mm drill bit.

Deck

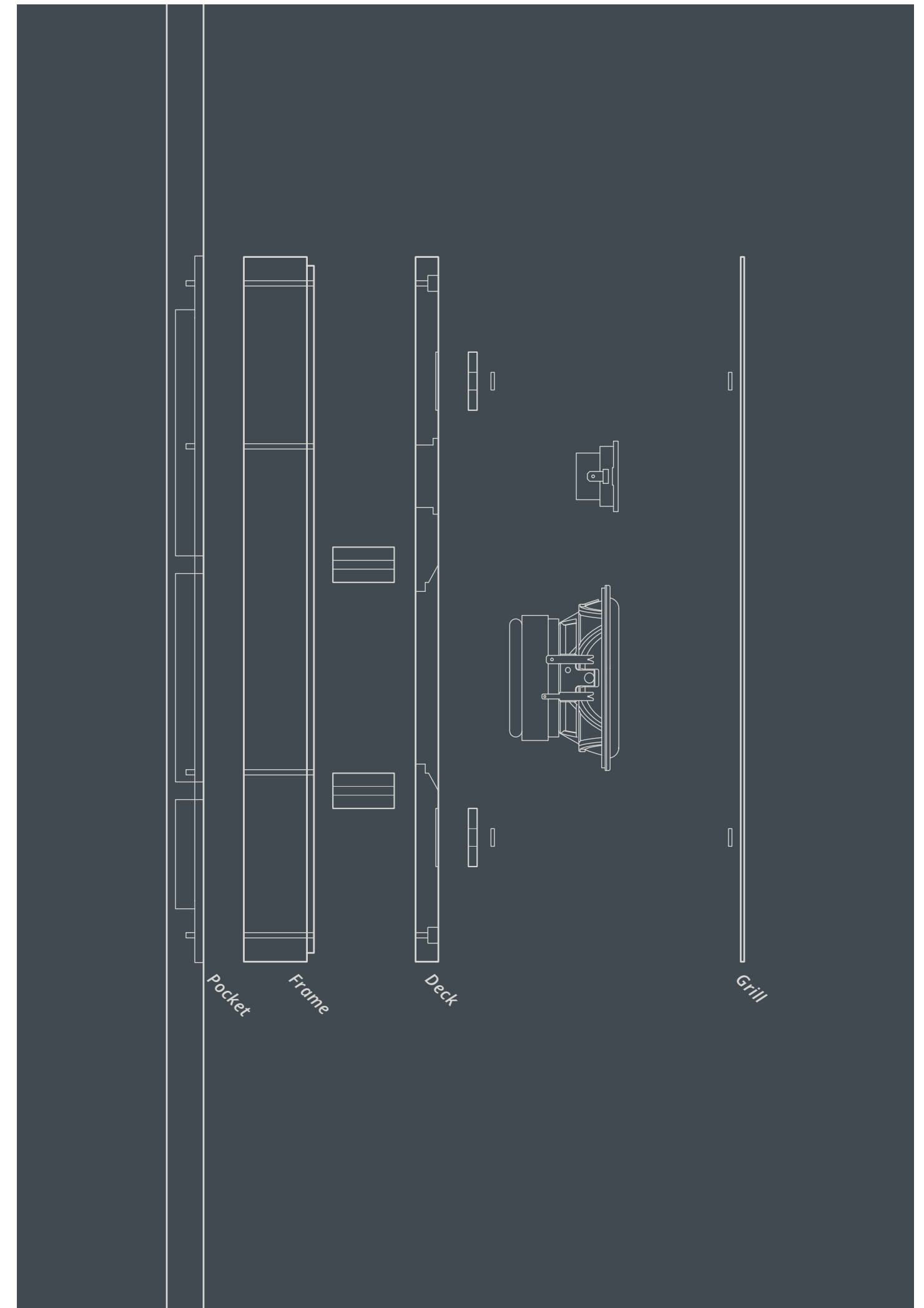


The deck is milled from the top side to 13mm thickness. The deck is milled with 10mm ball end mill, 10mm flat end mill, and holes are drilled with 3mm drill bit.

Grill



The grill is simple, but time consuming to mill. It is drilled with 3mm drill bit, and cut out with 4mm mill.



Assemblies

a)

The frame has a ridge for sealant. The sealant should be applied also in between the pocket, and the frame. I suggest 1-2mm thick, and maximum 5mm wide sealant strip.

b)

9 x dampening blocks

The right sized blocks are placed in the slots between the ribs. The material should be something soft, but not "air tight". It should allow the air flow through its membranes.

c)

4 x braces

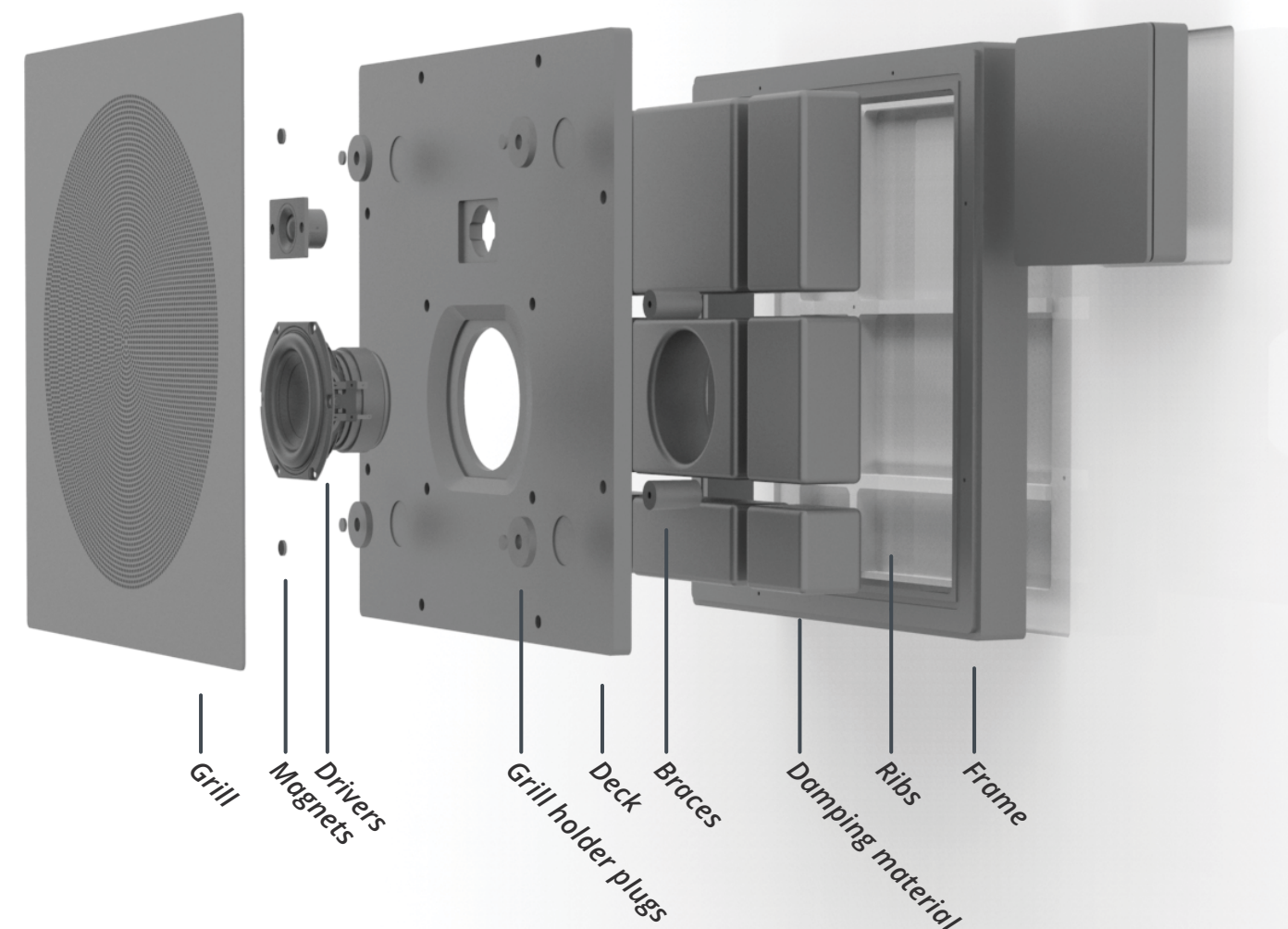
The braces are placed and fastened with screws through the deck. The frame and deck has screw holes for positioning all the parts. The braces can be either 3D printed or made by hand.

d)

4 x grill holders

8 x magnets

The grill holders are placed and glued in milled pockets. The magnets are placed in the holes of the holders. The grill magnets are placed on the correspondant place to meet the magnets on deck. The holders are dimensions are based on the 2.5 x 10mm magnets. If the size of magnets change, one must consider changing the holder dimensions. The holders can be 3D printed or made by hand.





Notes about open design

Open-design, or designing for open product has been a very teaching experience. It has forced me to change the way of thinking. Often in conceptual product design, it is easy to design something, and think like: "somewhere in the world there is a factory where this part can be made." In this case, I had to step into the local manufacturer's shoes, and think how he/she would manufacture the product with available tools.

Here I will conclude some aspects that I have been thinking or faced during the process. These aspects, again, are very relative. The experience might vary depending on what kind of machines are available, what are the materials, and skill level of the maker. All in all, I can say that the process has been more like finding what is not working than finding what is working. And, therefore finding the way to play within the constraints. The following notes are things which I bumped into and does not mean that every open design project would face the same things. Designing for open design is somehow trying to find the balance between universal rules, but still taking into consideration local aspect.

The processes in open design are hard to standardize, and therefore the results might vary a lot. If the result is wanted to be consistent, the maker should always use same tools, materials, paints, etc. But, also something to consider is that, is the product intended for distribution, or is it just one-off piece. What is most important, one should always try to learn and improve the processes, which is the best thing in open-design. Another good thing is that everybody is invited to improve the products that makers use and develop.

The following notes might sound very basic knowledge, but often they are very dependent on the subject of the design. Everything here is relative.

Material

The used material affect a lot to the end result, but also for how much hand work is required. For example, MDF is easy to mill, it rarely splits, and it is easy to sand. Painting MDF, instead needs more work than other materials, as it sucks the paint easily. On the other hand Plywood is easy to paint, but splits easily and is not very nice to sand. If plywood splits, the product is either ruined or requires a lot of fixing and more handwork.

Probably the best materials are synthetic, like Corian, which I used in the BeoCreate Core. It is accurate to mill, does not need sanding, and is easy to paint. The downside of Corian, and many other synthetic materials is the availability. Also, something else to consider is whether to use "dead" or "alive" material. Nature-based materials tend to "live" after manufacturing, while dead maintain their form. But, if "live" materials are treated properly, they are quite stable.

Material thickness is a crucial thing to consider, as when one mill the material, its tensions change.

Tools

Another factor for how much handwork is needed is the milling strategy. If the milling is done well, there is almost no handwork required. On the other hand, the mill ends are different, and leave different result on the surface as well. Rule of thumb: the bigger tool, the better result. The bigger tends to leave smoother surfaces, and the work does not stress the tool too much.

Which tool one should use, depends a lot on what is the material, what kind of forms one is milling, how fast one wants to mill.

Tolerances

Never underestimate tolerances. How much there should be, depends a lot on the material and construction of the product. Something that I learned is to leave space for the paint. 0.5mm paint thickness might sound nonexistent, but might affect the fittings quite dramatically.

Different materials also need a bit different tolerances. That must take into consideration when 3D modeling the product. For example, MDF requires more tolerance than Corian. That is because MDF is not as "accurate" material than Corian.

Manufacturing

The main intake what I tried to do, is to reduce the steps and points where something might go wrong. I noticed that often when I faced some friction in the process, it started to accumulate. The small problem was suddenly a big problem and in the worst case, ruined the whole product. So, when designing for openness it would be very good if one could prototype all the way through the process. Learning from mistakes is the key thing in open-design and local manufacturing.

Turning the product into a service

I believe that if this product would be turned into a service, the customer journey have to be as easy as going into a audio store and buy speakers from there. As the user research pointed, there might be some mental hesitance in buying the system from local manufacturer. Therefore it is very important to lower the mental barrier with branding and, better service than the store would offer.

If the product would be turned into a service it would require a branded website. In the website a person can design and define all the measurements, colours etc. of the system, order it and receive other information. The website is in the key position in the business where the design is distributed digitally around the world.

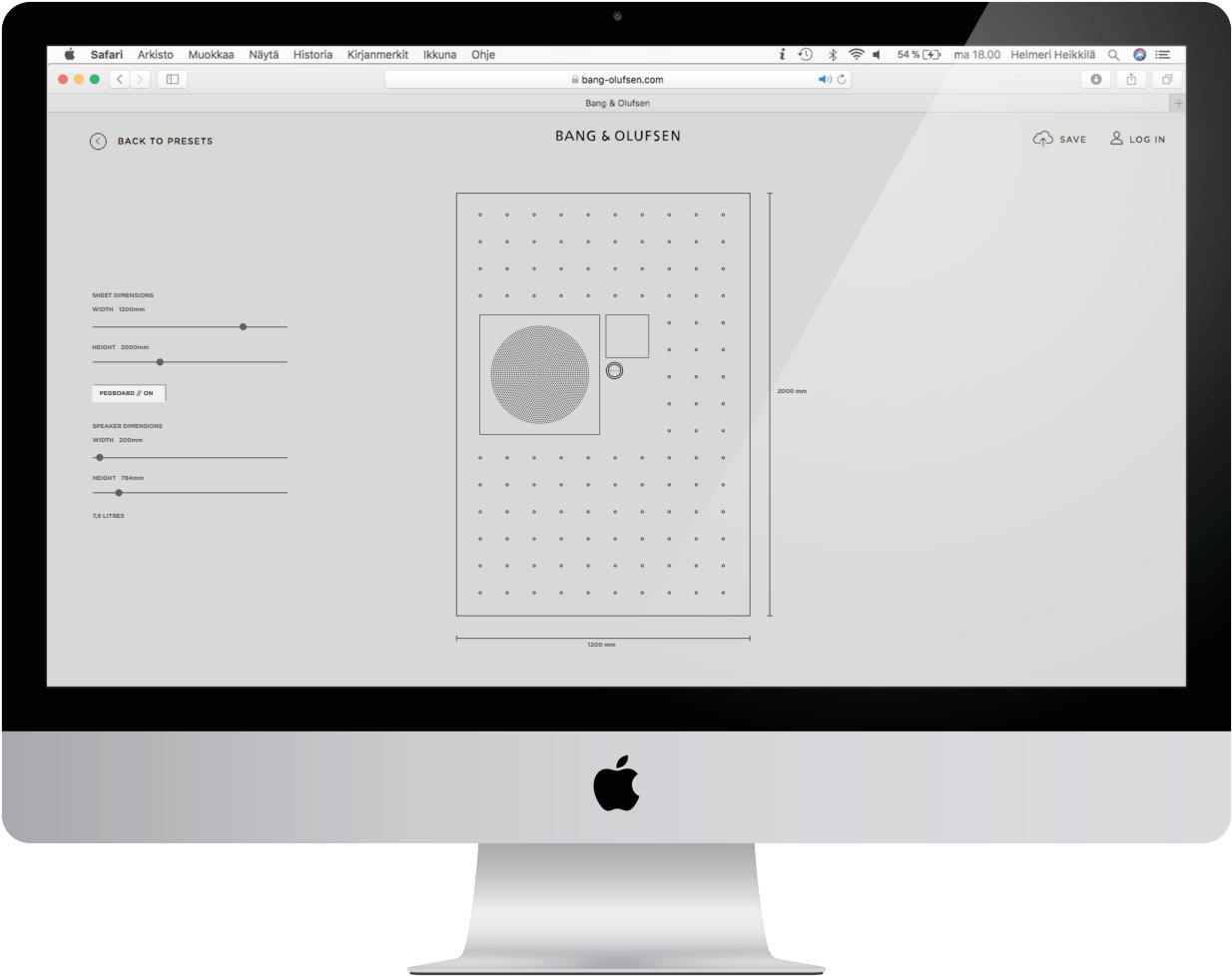
Other things that should be taken care of, is offering the proper guides for manufacturing, and maintaining good relationships with local suppliers and manufacturers.

I believe that there is endless amounts of challenges in this sort of business, and aspect that I can not predict and explain here. But, this is how far I have thought it in the context of this thesis.

Here I sketched the possible customer journey and web based interface.

Customer journey

1. *A person needs a new piece of interior, and sound to his/hers life.*
2. *He/she goes to a website, and designs the needed solution in there.*
3. *After a couple of hours he/she goes to a local manufacturing site to collect the ready piece.*



» Sketch of an web based interface where one could define the exact measures for the speaker, order it from local makerspace, and get exactly what is needed.

Chapter 5: Last words

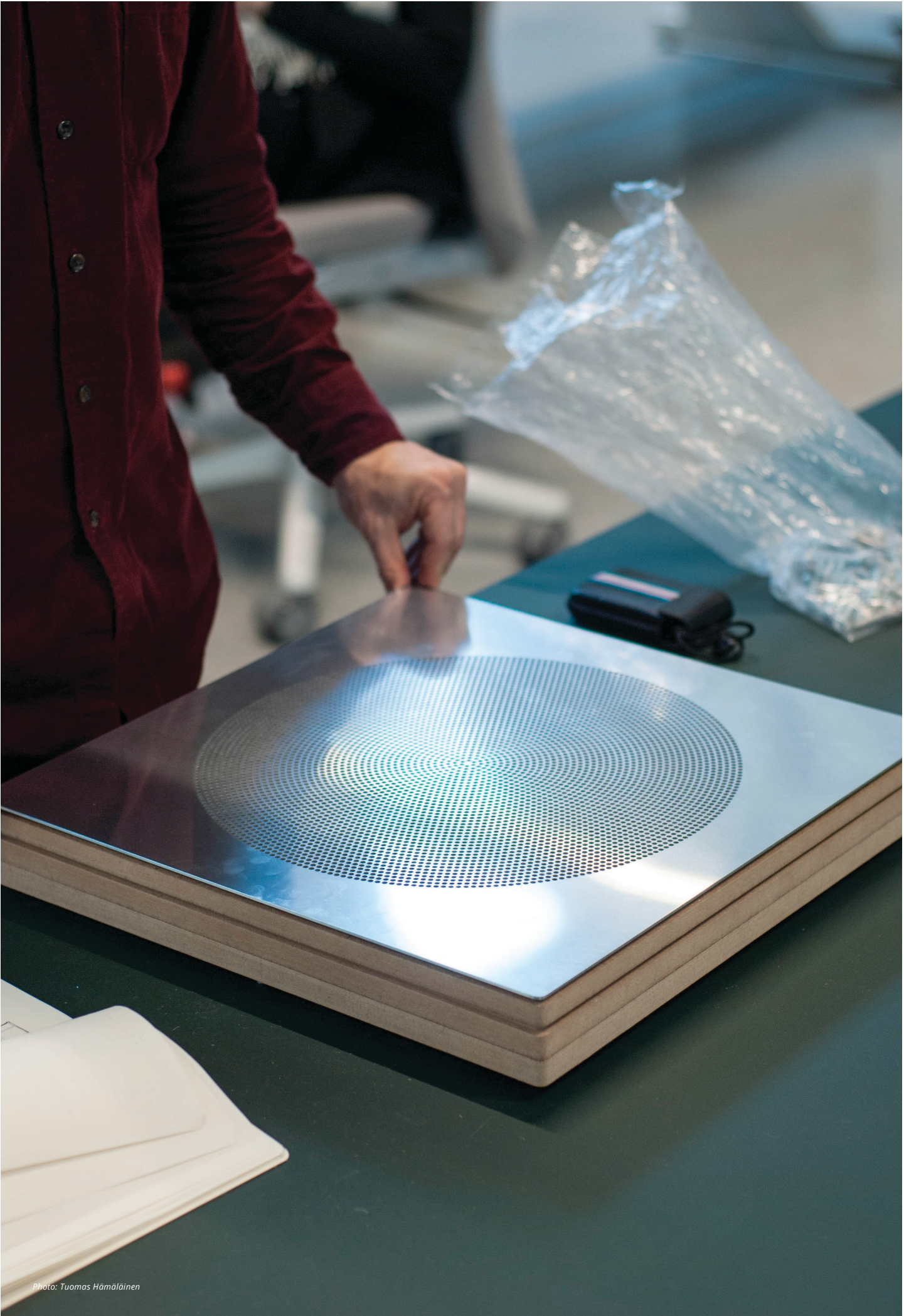


Photo: Tuomas Hämmäläinen

Discussion

The objective of this thesis was to design a loudspeaker system which could power new collaborations. Another objective was to look how open design and local manufacturing could contribute to sustainability in loudspeaker context. As a result, I proposed a product which takes into account the current principles of open design and possibilities in local manufacturing. The design is done keeping in mind that it should be generative, and accessible to many people around the world. The result is simple, and offers a playground for variations. I base the result on my own experience working in makerspace, and designing product in that context. I must note that this thesis concerned only the cabinet of the speaker, not hardware and its supply chains. The drivers and hardware still come from overseas. But, still, I am quite sure that we managed to reduce the shipping, and do decentralized product.

I have kept myself as a validating person for the manufacturing, but what the thesis lacks, is user validation. We don't know how feasible the idea is, but based on the feedback we have got from inside of Bang & Olufsen, everybody has shown interest towards the idea, and the product.

I referred Bonvoisin in earlier chapters: open design, and local manufacturing could improve sustainability by offering adaptability, value for local ecosystem and shorter transportation loops. As a conclusion, I have offered adaptability, the possibility for local manufacturing, and shorter transportation loops. Reflecting that to Bonvoisin, I have contributed to sustainability. But, what made it possible is the design for local manufacturing, and openness. To provide feasible and desirable locally made open products in the future, we must explore the principles of open design, and new possibilities in local ecosystems.

During the process, I realized that there is a reason why open-design products are relatively simple, but also that the meaning of simplicity is very relative. The same process might be very different for different persons. That is why we need to keep developing open-design practice, to lower the barriers for local action. The more people would practice open-design, the more sustainable products we could use.

Therefore, should I say that we should have more spaces which encourage local action? Fab labs are a good example that sort of spaces. I managed to make a fully working technical product, which does not look bad. It was designed for local mass manufacturing, so why couldn't we use, and develop more locally made, more advanced products?

The basics of sustainability, open design and local manufacturing were presented to find a new proposal for loudspeaker design. Instead of finding an answer to specific research question, I found it more valuable to look for new practice, and explain my experiences in this emerging field. The project is a good example of how we could start designing products for new business and distribution models. Still, the thesis does not propose anything new to the sustainable strategies, but more like uses the existing ones in a whole new context.

Contribution to the field from my opinion is that the thesis proves the potential of designing for local manufacturing. For further research the principles of open-design should be discovered, and how different principles might cause a different kind of products? What is global in local context? Could we find new synergies between seemingly unrelated products, or different parties? If we assume that business drives the sustainable chan-

ge, it would be also very beneficial look how new business models, and different principles of open design could go together.

As we know, the old tricks doesn't heal the world, we must adapt, and figure out new ways if we want to cope with new challenges. We have to start thinking holistically and try to observe every aspect of our consumption and behavior. Integrating, and considering sustainability as a starting point we can start to change peoples attitudes and behavior. It begins with organizational structures and strategies, and drains down to specific actions in product design. I believe that brave concepting is a good way to start that change, and in that process, design-driven innovation works just perfectly. I doubt that the result would be the same if I had followed more user-centered design processes. The design-driven innovation process is here proven to work, and be able to propose new products. It is great to see that companies like B & O are willing to invest in these sort of projects, which does not cause immediate profit, and we need to continue on this path. Next question is how Bang & Olufsen will turn this kind of experimental projects into monetary profit?

If we all agree that local manufacturing and open design are promising, emerging practices in the field of design, why it is not taught in schools yet? We, students of design are the future of design. Should we start teaching and looking more into open-design?

Future perspectives – Change has to be business

The truth is that we are living in the world where our actions need to make a profit. To make the change possible with this kind of products, it needs to become a business as well. The business might have a bad sound in it, but business makes the change even more powerful as then it might attract other parties as well. This project is a good example of it. I bumped into the Open desk, and how they have managed to create a business around open-design product. Ever since I have kept the business aspect in my mind. That is a good example how ideologies multiply.

BeoCreate Elements is planned to work with the same model than Open desk, providing the blueprints for free, but also charging if somebody wants the product readymade for themselves. Designing sound system for different spaces also requires some specific knowledge, which could be part of the business as well. Therefore the product would eventually turn to PSS, (Product-service system) which is considered as one of the most promising sustainable business models.

I had a good discussion about the subject with Christian, my advisor. He pointed out a good point that, even if this created some business, there would have to be a continuation from this stage. With continuation, I mean new applications and designs based on the same ideology. As I see the design at the moment, it already allows us to create different applications from it. For example, a scalable speaker without wall mounting, or mounting the speaker as a whole inside the structures.

Another issue is the markets. Assuming that people who are willing to use a flat sheet-made interior solutions in their homes, would be ready to incorporate sound in them, there could be some demand. Based on the knowledge from Christian, the custom installation markets are mainly in the U.S. But on the other hand, this product is different from those markets. It is hard to estimate what is the interest, as the whole concept is entirely new. But the good thing is that, the product would be manufactured always on-demand, which means no stocking products. This sort of distribution, and business could be run from a small room, without heavy early investments.

During my previous project with Bang & Olufsen, I got an idea where there would be B & O hubs in the cities where local manufacturers, craftsmen, artists, etc. could collaborate. My thesis and the concept could potentially work in this sort of hubs, and provide customized solutions locally for the ones who need them. But still, the loudspeaker design would be open allowing people with motivation and skills to develop the products further with no restrictions.

B & O Hub would create small local business for the big company and by no means would be huge income, but more like brand improvement action, and a meeting point with creatives who could provide new perspectives for the company. Maybe it should be even called BeoCreate Hub.

The small alike businesses and production facilities are already up and running in Copenhagen, for example, Underbroen. They have been forerunners in providing the facilities for urban production, manufacturing and pushing small businesses forward. These places are more than prototyping and collaboration spaces; they are also small local factories with digital tools empowering the local community. The same sort of action still lacks from Helsinki, which will be changing in the future.

So what would be the next step for the project? If we took the project further, the following steps would be starting to create a service system around the product. With the service I mean, website, well-working parametric model, design configuration and modification etc. Besides, we would need to decide what is provided by us, and what remains as a responsibility of makers. The way we could execute this varies, from full design service to just providing the blueprints. Anyway, it will require shit loads of work. Let's see.



Reflection

Hardly ever design processes go as they were planned, and the same applies to this case. My process started very traditionally with background, and user research, but when I got my hands dirty, the process began to take some sidesteps. It felt very distressing, but that might be because of an experimental process where I have to deal with subjects that I am not familiar at all. On the other hand, it is also a nature of an innovation process where there rarely is any similar examples to look at.

In practice the nonlinear process was testing something, finding an answer, going back and trying something else. Something that I felt I should have done more is to define the process, trust on it, and have the courage to follow it. But on the other hand, the free process gave me an opportunity to wander between different ideas. In the end, the wandering resulted problems in time, and project management. I spent too much time with the overall concept, and too little time with actual product design. I am very happy with the concept, and the whole ideology, but I would like to do another iteration with the design. For next time, when the concept is defined, it should be frozen, and then focused on design. I guess the best learning here was that in this kind of process, the decisions have to be assessed fast, and stick to good ideas and let bad ideas go. Always fast. Another intake for myself is that the messy project taught me how to go through a similar innovation process in the future.

During the process, Christian and everybody else was very helpful, and after the first hesitance, it started feeling that I can get all the help from the company I needed, which was great. I learned a lot how corporations work, the benefits and downsides. It was super nice to see how the company culture and passionate people work.

In the future, to benefit both, company and student, I would still recommend that when this sort of project starts, the timeline, steps, process, etc. would be clearly defined, and followed. That would potentially, support the process of student, but also the company, because it also ensures that company gets what it needs, in time.

Professionally I feel that I've found an exciting field to look for. The whole concept of openness in innovation, and design is something very promising. But, also the practice of open-design and local manufacturing is near to my natural way of working. It combines the workshop experimenting with greater cause, and new possibilities. That is definitely something that I will be developing in the future.

Comments

"The BeoCreate Elements explore a potential future not just for makers and hobbyists, but for people who desire custom made solutions optimized for their spaces. The systematic thinking behind Joska and Tuomas's thesis demonstrates that open design and distributed manufacturing has potential to lower the barriers for people to attain affordable designs made for you, going beyond CMF (color, material, finish) customisation. I consider myself privileged to have been part of the journey Joska undertook and forever grateful for the valuable insights that were uncovered from the BeoCreate Elements project. It is with great expectations that one day we at Bang & Olufsen are able to offer our discerning customers locally manufactured solutions made for their curated lives. I sincerely hope that I get to collaborate with Joska in the future and thank him for the excellent work that has a meaning and purpose that goes beyond 'creating nice stuff'".

- Christian Thams, Concept Manager Bang & Olufsen, Maj 7th 2018

"Every now and then, a new way of thinking rises in the field of architecture & design, and outdates old methods. It is refreshing to see that Joska's work is one of them. Open-design principles together with wall integration is very tempting for architects & building ingenieurs. It opens a whole new array of possibilities combining sound, and space in different environments.

As Churchill told us once, we shape our buildings, thereafter they shape us. This creation definitely leads us in the right direction, and indeed, new exciting shapes."

- Jaakko Heikinheimo, Architect

Thank you!

Tuomas Hämäläinen for collaborating with me in this project. *(For further reading, consider looking into Tuomas's thesis: BeoCreate Elements: a journey into the world of open-source audio.)*

Julia Noschis for the best comments and support.

My family for always being there.

Christian Thams for providing me this great thesis opportunity.

All the people at Bang & Olufsen for being very inspiring bunch of people.

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Simo Puintila for starting the collaboration with Bang & Olufsen.

Ville Arkonkoski for your expertise in milling.

Heidi Paavilainen for constructive feedback.

Eero Miettinen for sharing your decades long expertise in design.

Attachments

Questionnaire

What do/would you require from your speaker system?

The most important was obviously sound quality. That is default. Other answers which were often mentioned were: Easiness to connect with different sources, simplicity and timelessness, movable and extendable, relatively small size and possibility to repair.

"Quality sound, easy use, nice design, robustness and easy to repair"

The results gathered were in the end quite obvious, but still they proved my assumptions right which is was needed. Other question about the needs regarding the needs was more about is there something else that loudspeakers should fulfill.

Do speakers represent something else than sound for you?

The speakers were considered to convey the sense of style and be part of the interior. For some people speakers represented their lifestyle and passion for music. Speakers were also considered as status symbols that are showing the persons taste and lifestyle.

"Objects that are sending sonic waves into my direction"

"A nice speaker is also an important part of home decoration. It communicates cultural taste and values."

Do you expect something else than sound from your speaker system?

The most common answer was ease of use and simple aesthetics. Other important thing was connectivity with various devices and durability & longevity. But most interesting thing even thought there was only couple stating was the possibility to use speakers to control other home appliances too.

"Well of course the quality of the sound has to be good and also the system has to be reliable. It has to be personal."

"Easy connectivity. Possibly wireless. Easy wall mounting etc."

"Good looks and long-lasting quality."

If you would have to replace your existing system, what would be the reason for that? In which kind of circumstances you could imagine this would happen?

The most common answer was if the old one broke, or if one could get more money to buy better quality speakers. Other reason was if the space/interior changed due to a moving to smaller/bigger apartment. People saw replacing also feasible idea if they needed more speakers to create a multiroom system. One clear answer was that if people wanted to get more sound from their speakers, they would replace them. Also if technological development has gone by and they needed to update/upgrade their system to meet new requirements.

"For a bigger apartment I would need more speakers to system or if I would have full portable small size speaker."

"General upgrade, when old system reaches end of life"

"Probably I'd like to try something higher-end stuff, but that would require better designed room and probably some acoustic improvements for the room as well. I have to admit I'd like to try some modern speakers with traditional looks, like Harbeths. That would probably mean as well that I should replace my amplifier as well."

"If a new product will come up with all the required features (Quality sound, easy use, nice design, robustness and easy to repair"

What kind of problems you have faced with your loudspeakers?

The most popular answers were that the connectivity was poor and cords all over the place are irritating. Interestingly many people said that they had problems in placing their speakers. Something related to that is the equalization was seen to be hard or its lacking. Challenging repairability was also seen as a problem.

"Huoneiston akustiikka ei ole samalla tasolla kuin kaiuttimet."

"When big party, not enough base. Also difficult to decide where to place on the wall."

"Besides that I have had little headache with positioning my stereo speakers, and trying to find the best acoustic performane in my living room which isn't acoustically best."

Quotes:

- "A modular system becomes a "playground" for customisation."

- "what you see is what you get". - "Locally produced speaker, that's cool."

- "Rustiikkinen köpissuunnittelu kajari."

- "Upgrading" speakers based on needs"

- "A9 on jotenki hassu tms."

- "If you have to have object in your room, it has to look nice. But the purpose of the object is not to look nice, its purpose is to make sound."

Focus group interview

Richard, 27, student, M:

- Small speakers all over the place. Music flooding all over.
- At home, background music.
- Likes to listen to vinyl records.
- Portable speakers like!
- The soundbar on the wall, on the floor. eg. mirror.
- The same long shapes goes together.
- Remote/voice control, not phone/tablet.
- Small speaker for small apartment, bigger for big apartment
- Let's not necessarily change the speaker, but to relocate it to a space/purpose that it's better suited for.
- Natural materials, contrasts in design
- Customization is ok, if made easy.
- Taking parts off, changing form/colour
- Buying from local manufacturer ok. Kiehtova ajatus. To see how speaker is done. To see the manufacturing chain.
- Could do a speaker by himself.

Waltteri, 27, working, M:

- Small ones to kitchen, bigger ones in livingroom and bedroom.
- Depends a lot about knowledge how they should be arranged
- Appearance / usability compromise
- Don't want to see speakers, doesn't want to feel being surrounded by speakers
- Ability to buy more speakers later that match the existing ones
- Preferably another speaker rather than making one bigger
- Small, invisible, good sound.
- Customization ok, but has to be easy.
- Want to decide where the speaker is.
- Nice wooden object, but speaker. That works.

- Not appealing buying speaker from local manufacturing facility.
- Too much effort, doesn't know what to want if haven't seen one.
- Rustiikkinen köpissuunnittelu kajari.
- App where he could choose materials / etc.?
- Needs a framework from where the customer could choose different options.
- Frameworks different in different cultures.
- B&O validation center, where designs can be submitted

Jenna, 25, student, F:

- Bigger speaker too dominative
- Smaller ones again in different spots
- Scalability maybe not at home
- Scalability when need of bigger speaker
- Aesthetic is important, have to look good, blends into interior
- Why not customizing?
- Customizing if having a special place where it's needed
- Interesting idea buying speaker from local manufacturing facility
- Getting closer to manufacturer. What you see is what you get.
- More personal connection to brand and product
- "Build-to-order" customisation much more appealing because less effort, if no significant cost increase.

Alfred, 34, working, M:

- Former disc jockey.
- Kitchen speaker, livingroom as well.
- Two big speakers in front and one smaller in back at livingroom.
- One smaller in kitchen, sound quality not critical because there are other sounds.
- Studio monitors at desk, not enough for filling the living room, too clinical/raw sound, need to sit at

the sweet spot and need to almost concentrate on listening to music.

-"Upgrading" speakers based on needs, e.g., bring a bedroom speaker to make living room speaker bigger.

-It's ok for a speaker to look like a speaker.

-Whole thing is detailed

-Attachment mechanism should be a part of the product.

-Should be no disconnect between how product looks and what it does.

-Rather conservative choices, choice of colour not necessarily important.

-A modular system becomes a "playground" for customisation.

-Maker spaces □ niche, the person has to be into it.

-Wants to buy, rather than make himself.

-A network of makers/craftsmen who would build the loudspeakers.

-Locally produced speaker, that's cool.

Christopher, 35, working, M :

-Multiroom system - Should still be controlled individually

-Using speakers with tv. Position of tv dictates the position of speakers

-Positioning them based on his knowledge, two point or maybe in the center of the room

-Free movement and room calibration

-It all come down to quality of the sound - Sensation of sound

-Design of the speaker is not the point

-"If you have to have object in your room, it has to look nice. But the purpose of the object is not to look nice, its purpose is to make sound."

-Designing the system and picking the right ones to his own room

-5-8 hours for building a speaker

-Not asking people to solder

-The trend shows that the kits comes with the tools and that would be good

-Local production fixes the problem of warehouse management

Conclusion

-Small speakers were seen more as a one point (kitchen) speakers

-Generally smaller speakers were seen more feasible

-Multiple speakers popular, rather than one-point systems.

-Room adaptation, because people didn't know how to place them correctly

-Most compelling use case for modularity is when bigger sound is needed for some situations, like parties. Combine smaller units for larger sound.

-Also taking sound to outside.

-Putting more than one speakers together is seen as an option in some cases / Not making one speaker necessarily bigger.

-Placement: shelves most popular, wall.

-Sometimes other furniture dictates the placement of speakers

-Appearance seen as two-fold: humane & furniture-like can be on display, otherwise as hidden as possible.

-Clearly a dilemma between sound and design.

-Customization is seen feasible if its made easy. The one problem might be that, people don't know what they want until they see it.

-Local manufacturing adds value for the product.

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***“Open design is generative.
It is conducive to continuous
re-design, adaption, refine-
ment and extension. Open
design is a potent elixir that
mitigates stagnation and
awakens generative action.”***

-Michel Avital

Designing an open loudspeaker

Joska Helmeri Heikkilä

Master´s thesis 2018
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